

Automatic rail-weighbridges

Part 1: Metrological and technical requirements – Tests

International Organisation of Legal Metrology (OIML)

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EXPLANATORY NOTE

This working draft revision of OIML R 106-1 developed by the OIML subcommittee TC 9/ SC 2 *Automatic weighing instruments*, following consultations in 2004 for the need to update the technical and metrological specifications in the Recommendation in line with developments in the instrument and in legal metrology.

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FOREWORD

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TERMINOLOGY (Terms and definitions)

The terminology used in this Recommendation conforms to the *International Vocabulary of Basic and General Terms in Metrology* (VIM, 1993 edition) and the *Vocabulary of Legal Metrology* (VIML, 2000 edition), the "OIML Certificate System for Measuring Instruments" (2003 edition) and other relevant OIML documents. In addition, for the purposes of this Recommendation, the following definitions apply.

T.1 General definitions

T.1.1 Mass

A physical quantity the base unit of which is the kilogram.

T.1.2 Load

An object of determinate mass

T.1.3 Weights

The standard test weights used for the type examination or verification of an instrument meeting the metrological requirements of OIML R 111, Bibliography [1].

T.1.4 Weighing

The process of determining the mass of an object from the effect of gravity on that object.

T.1.5 Weighing instrument

A measuring instrument that serves to determine the mass of an object by using the action of gravity.

The instrument may also be used to determine other quantities, magnitudes, parameters or characteristics related to the determined mass.

According to its method of operation, a weighing instrument is classified as automatic or non-automatic.

T.1.6 Automatic weighing instrument

An instrument that weighs without the intervention of an operator and follows a predetermined program of automatic processes characteristic of the instrument.

T.1.7 Rail-weighbridge

A weighing instrument having a load receptor, inclusive of rails for conveying railway vehicles.

T.1.8 Electronic instrument

An instrument equipped with electronic devices.

T.1.9 Control instrument

Weighing instrument used to determine the conventional true value of the mass of the reference wagons.

Control instruments used for testing may be:

- separate from the instrument being tested, or
- integral, when a static weighing mode is provided by the instrument being tested.

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T.1.10 Conventional true value (of a quantity)

A value attributed to a particular quantity and accepted, by convention, as having an uncertainty appropriate for a given purpose. [VIM 1.20]

T.1.11 Metrological authority

An authorized representative of the national service of legal metrology, with responsibility for ascertaining and confirming that the instrument satisfies all or some of the requirements of this Recommendation.

T.1.12 Accuracy of a measuring instrument

The ability of a measuring instrument to give responses close to a true value [based on VIM 5.18].

Note: Accuracy is a qualitative concept.

T.2 CONSTRUCTION

Note: In this Recommendation the term «device» is used for any means by which a specific function is performed irrespective of the physical realization e.g. by a mechanism or a key initiating an operation; the device may be a small part or a major portion of an instrument.

T.2.1 Controlled weighing area

A place specified for the operation of instruments for weighing wagons in motion which is in conformity with the installation requirements given in Annex B.

T.2.2 Weigh zone

Zone comprising the load receptor on which a wagon must be located when it is weighed.

T.2.2.1 Apron

A part of the weigh zone that is not the load receptor but which is located on either end of the load receptor.

T.2.3 Load receptor

The part of the instrument intended to receive the load.

T.2.3.1 Single load receptor

A load receptor that can support:

- all the wheels of a wagon simultaneously for full-draught weighing, or
- all the wheels of an axle simultaneously for axle partial weighing.

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T.2.3.2 Multiple load receptors

Two or more load receptors placed in series that are used as a single load receptor for full-draught weighing.

T.2.3.3 Load-transmitting device

Part of the instrument for transmitting the force produced by the load acting on the load receptor to the load-measuring device.

T.2.3.4 Load-measuring device

Part of the instrument for measuring the load, and an indicating device.

T.2.3.5 Load conveyor

Device to move the loads on to and off the load receptor.

T.2.3.6 Load transport system

The system used to transport the load over the load receptor.

T.2.4 Electronic instrument

An instrument equipped with electronic devices.

T.2.4.1 Electronic device

A device comprised of electronic sub-assemblies and performing a specific function. An electronic device is usually manufactured as a separate unit and may be capable of being independently tested.

T.2.4.2 Electronic sub-assembly

A part of an electronic device comprised of electronic components and having a recognisable function of its own.

T.2.4.3 Electronic component

The smallest physical entity that uses electron or hole conduction in semiconductors, gases, or in a vacuum.

T.2.5 Module

Identifiable part of an instrument that performs a specific function or functions, and that can be separately evaluated according to the metrological and technical performance requirements in the relevant Recommendation. The modules of a weighing instrument are subject to specified partial error limits.

Note: Typical modules of an automatic weighing instrument are: load cell, indicator, analogue or data processing device, terminal, weighing module and remote display.

T.2.5.1 Load cell

Force transducer which, after taking into account the effects of the acceleration of gravity and air buoyancy at the location of its use, measures mass by converting the measured quantity (mass) into another measured quantity (output) [OIML R60 (2000) Bibliography [2].

Note: Load cells equipped with electronics containing amplifier and analogue-to-digital conversion (ADC), and data processing (optionally) are called digital load cells

T.2.5.2 Indicator

Electronic device of an instrument that may perform the analogue-to-digital conversion of the output signal of the load cell, and further processes the data, and displays the weighing result in units of mass.

T.2.5.3 Analogue data processing device

Electronic device of an instrument that performs the analogue-to-digital conversion of the output signal of the load cell, and further processes the data, and supplies the weighing result in a digital format via a digital interface without displaying it. It may optionally have one more keys to operate the instrument.

T.2.5.4 Digital data processing device

Electronic device of an instrument that further processes the data, and supplies the weighing result in a digital format via a digital interface without displaying it. It may optionally have one or more keys to operate the instrument.

T.2.5.5 Weighing module

That part of the weighing instrument that comprises all mechanical and electronic devices (i.e. load receptor, load-transmitting device, load cell, and analogue data processing device) but not having the means to display the weighing result. It may optionally have devices for further

processing (digital) data and operating the instrument.

T.2.5.6 Terminal

Digital device that has one or more keys to operate the instrument, and a display to indicate the weighing results transmitted via the digital interface of a weighing module or an analogue data processing device.

T.2.5.7 Remote display

Terminal without keys that can be used for the primary indications or for their repetition.

T.2.6 Ancillary devices

T.2.6.1 Zero-setting device

Device for setting the indication to zero when the load receptor is empty.

T.2.6.1.1 Non-automatic zero-setting device

A zero-setting device that must be operated manually.

T.2.6.1.2 Semi-automatic zero-setting device

A zero-setting device that operates automatically following a manual command.

T.2.6.1.3 Automatic zero-setting device

A zero-setting device that operates automatically and without the intervention of an operator.

T.2.6.2 Zero-tracking device

A device for maintaining the zero indication within certain limits automatically.

T.2.6.3 Printing device

The means to print the weight values of wagons weighed on the instrument and/or a summation of those wagon weights.

T.2.7 Software

T.2.7.1 Metrologically relevant software

Programs, data and type-specific parameters that belong to the measuring instrument or module, and define or fulfil functions which are subject to legal control.

Examples of metrologically relevant data are: Final results of the measurement, i.e. gross, net and tare / preset tare value (including the decimal sign and the unit), identification of the

weighing range and the load receptor (if several load receptors have been used), software identification.

T.2.7.2 Metrologically relevant parameter

Parameter of a measuring instrument or a module subject to legal control. Such parameters comprise calibration parameters (e.g. span adjustments or corrections) and configuration parameters (e.g. maximum capacity, minimum capacity, units of measurement, etc). They are adjustable or selectable only in a special operational mode of the instrument may be classified as those that should be secured (unalterable) and those that may be accessed (settable parameters) by an authorised person.

T.2.7.3 Software identification

A sequence of readable characters of software, and that is inextricably linked to the software (e.g. version number, checksum).

T.3 Metrological characteristics

T.3.1 Weighing

T.3.1.1 Full draught weighing

Weighing a wagon that is entirely supported on the load receptor(s).

T.3.1.2 Partial weighing

Weighing a wagon in two or more parts on the same load receptor. The results are automatically added to indicate or print the wagon weight.

T.3.1.3 Weighing-in-motion (WIM)

Weighing wagons that are in motion.

T.3.1.3.1 Uncoupled wagon weighing

Weighing-in-motion of wagons that travel independently across a load receptor. (This is usually achieved by means of an incline of the approach to the load receptor).

T.3.1.3.2 Coupled wagon weighing

Weighing-in-motion of a train of coupled wagons to obtain a weight indication or printout of the individual wagons.

T.3.1.3.3 Train weighing

Weighing-in-motion of a number of coupled wagons to obtain a totalized weight of all the wagon weights.

T.3.1.4 Static weighing

Weighing a wagon while stationary and uncoupled to obtain a mass for the purposes of testing.

T.3.2 Capacity

T.3.2.1 Maximum capacity (Max)

The largest mass that an instrument is designed to weigh-in-motion without totalizing.

T.3.2.2 Minimum capacity (Min)

The mass below which a weighing-in-motion results before totalizing may be subject to an excessive relative error.

T.3.3 Wagon weight

T.3.3.1 Maximum wagon mass

The largest in-motion weight that an instrument is approved to for a particular site.

T.3.3.2 Minimum wagon mass

The wagon mass below which a weighing-in-motion result may be subject to an excessive relative error.

T.3.4 Scale interval (d)

A value expressed in units of mass for weighing-in-motion that is the difference between:

- the values corresponding to two consecutive scale marks for analogue indication, or
- two consecutive indicated or printed values for digital indication.

T.3.4.1 Scale interval for stationary load

The scale interval used for static tests.

T.3.5 Speed

T.3.5.1 Maximum operating speed (s_{\max})

The greatest velocity of a wagon that the instrument is designed to weigh in-motion and above which the weighing results may be subject to an excessive relative error.

T.3.5.2 Minimum operating speed (s_{\min})

The lowest velocity of a wagon that the instrument is designed to weigh in-motion and below which the weighing results may be subject to an excessive relative error.

T.3.5.3 Range of operating speeds

The difference between the minimum and maximum operating speeds at which a wagon may be weighed-in-motion.

T.3.5.4 Maximum transit speed

The maximum speed that a railway vehicle can travel on the weigh zone without producing a permanent shift in the performance characteristics of a weighing instrument beyond those specified.

T.3.6 Warm-up time

The time between the moment that power is applied to an instrument and the moment at which the instrument is capable of complying with the requirements.

T.3.7 Durability

Ability of an instrument to maintain its performance characteristics over a period of use.

T.3.8 Final weighing value

Weighing value which is achieved if the instrument is completely in rest and balanced and there are no disturbances taking effect on the indication.

T.3.9 Stable equilibrium

In case of printing and/or data storage, the printed or stored weighing values do not deviate more than 1 d from the final weighing value (i.e. two adjacent values are allowed).

T.3.10 Discrimination

Ability of an instrument to react to small variations of load.

The discrimination threshold, for a given load, is the value of the smallest additional load that, when gently deposited on or removed from the load receptor, causes a perceptible change in the indication.

T.4 INDICATIONS AND ERRORS

T.4.1 Digital indication

An indication in which the scale marks are a sequence of aligned figures that do not permit interpolation to a fraction of the scale interval.

T.4.2 Errors

T.4.2.1 Error (of indication)

The indication of an instrument minus the (conventional) true value of the corresponding input quantity. [VIM 5.20]

T.4.2.2 Intrinsic error

The error of an instrument determined under reference conditions. [VIM 5.24]

T.4.2.3 Initial intrinsic error

The intrinsic error of an instrument as determined prior to performance tests and durability evaluations.

T.4.2.4 Maximum permissible errors (MPE)

Extreme values of an error permitted by specifications or regulations between the indication of a weighing instrument and the corresponding true value, as determined by reference standard weights, at zero or no load, in the reference position. [VIM 5.21]

T.4.2.5 Maximum permissible deviation (MPD)

Maximum permissible deviation of any wagon mass from the respective corrected mean of the same wagon weight.

T.4.2.6 Fault

The difference between the error of indication and the intrinsic error of a weighing instrument.

Principally, a fault is the result of an undesired change of data contained in or flowing through an electronic instrument. In this Recommendation, a "fault" is a numerical value.

T.4.2.7 Significant fault

A fault greater than 1 *d*.

The following are not considered to be significant faults:

- faults that result from simultaneous and mutually independent causes in the instrument or in its checking facility,
- faults that make it impossible to perform any measurement,
- transitory faults that are momentary variations in the indications which cannot be interpreted, memorised or transmitted as a measurement result,
- faults that are so serious that they will inevitably be noticed by those interested in the measurement.

T.4.2.8 Span stability

The capability of an instrument to maintain the difference between the indication of weight at maximum capacity and the indication at zero within specified limits over a period of use.

T.4.2.9 Maximum span stability error

A span stability error greater than one-half of the absolute value of the maximum permissible error applicable to the load.

T.4.2.10 Rounding error

The difference between a digital measurement result (indicated or printed) and the value of that measurement result with an analogue indication.

T.4.2.11 Repeatability error

The difference between the highest and lowest results of successive measurements of the same load carried out under the same conditions of measurement. [VIM 3.6]

Note: Repeatability conditions include:

- the same measurement procedure
- the same operator
- the same measuring instrument, used under the same conditions
- the same location
- repetition over a short period of time

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T.5 INFLUENCES AND REFERENCE CONDITIONS

T.5.1 Influence quantity

A quantity that is not the measurand but that affects the result of the measurement.

T.5.1.1 Influence factor

An influence quantity having a value within the specified rated operating conditions of the instrument.

T.5.1.2 Disturbance

An influence quantity having a value that falls within the limits specified in this International Recommendation but that falls outside the rated operating conditions of the instrument.

T.5.2 Rated operating conditions

Conditions of use which give the ranges of the influence quantities for which the metrological characteristics are intended to lie within the specified maximum permissible errors.

T.5.3 Reference conditions

Conditions of use prescribed for testing the performance of a measuring instrument or for inter-comparison of results of measurements.

Note: The reference conditions generally include reference values or reference ranges for influence quantities affecting the measuring instrument. [VIM 5.7]

T.6 Tests

T.6.1 Static test

A test with standard weights that remains stationary on the load receptor to determine an error.

T.6.2 In-motion (dynamic) test

A test with reference wagons that are in motion on the load receptor to determine an error.

T.6.3 Simulation test

A test carried out on a complete instrument or part of an instrument in which any part of the weighing operation is simulated.

T.6.4 Performance test

A test to verify that the equipment under test (EUT) is capable of accomplishing its intended functions.

T.6.5 Span stability test

A test to verify that the EUT is capable of maintaining its performance characteristics over a period of use.

T.7 Rail vehicles

T.7.1 Wagon

A loaded or unloaded railway goods vehicle that is recognized by the instrument as a vehicle to be weighed.

T.7.2 Reference wagon

A wagon of known mass that is typical of those to be used for weighing on the instrument and which has been selected for the purposes of in-motion testing.

T.7.3 Coupled wagon

A number of reference wagons coupled whose individual mass are to be obtained.

T.7.4 Total train

A number of coupled wagons whose totalized mass is to be obtained.

AUTOMATIC RAIL-WEIGHBRIDGES

1 General

1.1 Scope

This International Recommendation specifies the requirements and test methods for automatic rail-weighbridges, hereinafter referred to as “WIM instruments”, that are used to determine the mass of railway wagons when they are weighed in motion (WIM).

It is intended to provide standardized requirements and test procedures to evaluate the metrological and technical characteristics of such instruments in a uniform and traceable way.

1.2 Terminology

The terminology given in the terminology section shall be considered as a part of this Recommendation.

2 Metrological requirements

2.1 Accuracy classes

2.1.1 Wagon mass

For determining the wagon mass, WIM instruments are divided into four accuracy classes:

0.2 0.5 1 2

2.1.2 Train mass

For determining the train mass, WIM instruments are divided into four accuracy classes:

A B C D

2.1.3 Relationship between accuracy classes

The relationship between the accuracy classes for wagon mass and the accuracy classes for train mass are as specified in Table 1 below.

Table 1

Accuracy class Wagon	Accuracy class Train			
	A	B	C	D
0.2	✓	✓		
0.5	✓	✓	✓	
1	✓	✓	✓	✓
2		✓	✓	✓

Notes: (1) The limitation of accuracy classes to certain applications may be determined by national prescription.

(2) An instrument may be in a different accuracy class for wagon weighing than that for train weighing.

2.2 Maximum permissible errors

2.2.1 Weighing-in-motion

The maximum permissible errors for wagon or train weighing-in-motion shall be as specified in Table 2.

Table 2	
Percentage of mass of wagon or train, as appropriate	
Initial verification	In-service
$\pm 0.10 \%$	$\pm 0.20\%$
$\pm 0.25 \%$	$\pm 0.50\%$
$\pm 0.50 \%$	$\pm 1.00\%$
$\pm 1.00 \%$	$\pm 2.00 \%$

2.2.1.1 Wagon weighing

The maximum permissible error for wagon weighing, shall not exceed one of the following values, whichever is greater:

- a) the value calculated according to Table 2, rounded to the nearest scale interval;
- b) the value calculated according to Table 2, rounded to the nearest scale interval for the mass of a single wagon equal to 35 % of the maximum wagon mass (as inscribed on the descriptive markings), or
- c) 1 *d*.

2.2.1.2 Train weighing

The maximum permissible error for train weighing shall be one of the following values, whichever is greater:

- a) the value calculated according to Table 2, rounded to the nearest scale interval;
- b) the value calculated according to Table 2, for the mass of a single wagon equal to 35 % of the maximum wagon mass (as inscribed on the descriptive markings) multiplied by the number of reference wagons in the train (not exceeding 10 wagons) and rounded to the nearest scale interval, or
- c) 1 *d* for each wagon in the train but not exceeding 10 *d*.

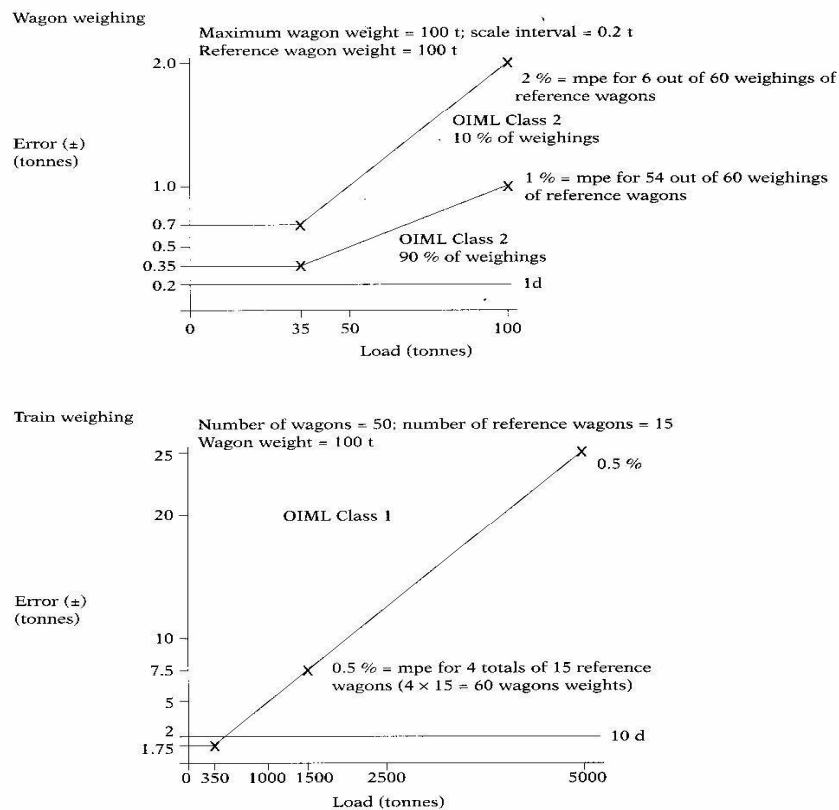
See Figure 1 for an illustration of this requirement.

On initial verification of an instrument weighing coupled wagons, the errors of not more than 10 % of the weighing results taken from one or more passes of the test train may exceed the appropriate maximum permissible error given in Table 2 but shall not exceed two times that value.

Figure 1

AUTOMATIC RAIL-WEIGHBRIDGES

Illustration of maximum permissible errors and in-motion test requirements for a sample train



2.2.2 Static weighing

The maximum permissible errors on static weighing for increasing or decreasing loads shall be the appropriate values in Table 3.

Table 3

Accuracy Class Wagon	Load (m) expressed in numbers of scale intervals	Maximum permissible errors	
		Initial verification	In-service verification
0.2 0.5 1 2	$0 \leq m \leq 500$	$\pm 0.5 d$	$\pm 1.0 d$
	$500 \leq m \leq 2\,000$	$\pm 1.0 d$	$\pm 2.0 d$
	$2\,000 \leq m \leq 10\,000$	$\pm 1.5 d$	$\pm 3.0 d$

Note: See Table 1 for the relationship between the accuracy classes for single wagon mass and the accuracy classes for the total train mass.

2.3 Scale interval (*d*)

For a particular method of weighing-in-motion and combination of load receptors, all mass indicating and printing devices on an instrument shall have the same scale interval.

The relationship between the accuracy class, the scale interval and the maximum wagon mass divided by the scale interval shall be as specified in Table 4.

Table 4

Accuracy class Wagon	<i>d</i> (kg)	(maximum wagon mass)/ <i>d</i>	
		Minimum	Maximum
0.2	≤ 50	1000	5000
0.5	≤ 100	500	2500
1	≤ 200	250	1250
2	≤ 500	100	600

Note: See Table 1 for the relationship between the accuracy classes for single wagon mass and the accuracy classes for train mass.

2.4 Scale interval for stationary load

If the scale interval for stationary load is not equal to the scale interval (*d*), it shall be automatically out of service when the instrument is in use for weighing-in-motion. In addition, if the instrument is not verified for use as a non-automatic weighing instrument, the scale interval for stationary load shall not be readily accessible and shall only be used for static testing.

2.5 Minimum capacity

The minimum capacity shall not be less than 1 *t*, and not greater than the value of the result of the minimum wagon mass divided by the number of partial weighings.

2.6 Minimum wagon mass

The minimum wagon mass shall not be less than 50 *d*.

2.7 Influence quantities

2.7.1 Temperature

2.7.1.1 Static temperature

Instruments shall comply with the appropriate metrological and technical requirements at temperatures from –10 °C to +40 °C.

For special applications, however, the limits of the temperature range may differ provided that this range shall not be less than 30 °C and shall be specified in the descriptive markings.

Instruments shall be tested in accordance with the static temperatures test in A.7.2.1.

2.7.1.2 Temperature effect on no-load indication

The indication at zero or near zero shall not vary by more than one scale interval for a difference in ambient temperature of 5 °C.

Instruments shall be tested in accordance with the static temperatures test in A.7.2.2.

2.7.2 Power supply

An electronic instrument shall comply with the appropriate metrological and technical requirements, if the voltage of the power supply varies between the lower (U_{min}) and upper (U_{max}) of the nominal voltage marked on the instrument:

- AC mains power supply: $U_{min} = -15\%$, $U_{max} = +10\%$
- DC mains power supply: U_{min} = lower operating limit
- 12 V or 24 V road vehicle battery operated instruments:
 - U_{min} = lower operating limit
 - $U_{max} = 16\text{ V}$ (for 12 V battery), and 32 V (for 24 V battery).

Note: The minimum operating voltage (U_{min}) is defined as the lowest possible operating voltage before the instrument is automatically switched off.

Battery-operated electronic instruments or instruments with external or plug-in power supply (AC or DC) shall either continue to function correctly or not indicate any weight values if the voltage is below the manufacturer's specified value, the latter being larger or equal to the minimum operating voltage.

Instruments shall be tested in accordance with the voltage variation tests in Annex A.7.2.

2.8 Units of measurement

The units of mass to be used on a WIM instrument are the kilogram (*kg*) and the tonne (*t*).

2.9 Agreement between indicating and printing devices

For the same load, the difference between the weighing results provided by any two devices having the same scale interval shall be as follows:

- zero for digital devices;
- not greater than the absolute value of the maximum permissible error for weighing-in-motion for analogue devices.

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2.10 Operating speed

Operating speed shall be determined by the WIM instrument as the average velocity of the wagon as it moves over the load receptor. This speed shall be indicated in km/h, rounded to the nearest 1 km/h. Operating speed shall be indicated and/or printed only after the entire wagon has been weighed in motion.

3 TECHNICAL REQUIREMENTS

3.1 Suitability for use

Instruments shall be designed to suit the vehicles, site and method of operation for which they are intended.

3.2 Security of operation

3.2.1 Fraudulent use

An instrument shall have no characteristics likely to facilitate its fraudulent use.

3.2.2 Accidental maladjustment

Instruments shall be constructed so that maladjustments likely to disturb their metrological performance cannot normally take place without the effect being easily detected.

3.2.3 Interlocks

Interlocks shall prevent the use of any control device that may alter a weighing operation.

3.2.4 Single (uncoupled) wagon weighing

Instruments used for single (uncoupled) wagon weighing shall recognize and indicate the following situations:

- a) the passage of two or more coupled wagons;
- b) the passage of two or more uncoupled wagons that is sufficiently close to cause either a malfunction of the instrument or errors exceeding the appropriate maximum permissible errors.

3.2.5 Automatic operation

Instruments designed for operation under circumstances where it is not possible to verify continuously their satisfactory performance shall provide a level of confidence “near to certainty” that the operation of the instrument is within the requirements of this Recommendation. The submitted documentation (A.1.1) shall include a description of how this condition is met.

The level of confidence shall take account of uncertainties of measurement, significant faults and failure of the instrument. If estimated by statistical methods, it shall be at least 99 %.

3.2.6 Use as a non-automatic weighing instrument

In addition to complying with the requirements of OIML R76 Bibliography [3] for class III or class IIII non-automatic weighing instruments, an instrument that can operate in a non-automatic mode shall be equipped with an enabling device for non-automatic operation that prevents both automatic operation and in-motion weighing.

3.3 Zero-setting device

An instrument shall have one or more zero-setting devices and shall not have more than one zero-tracking device for each load receptor. These devices may be:

- non-automatic, or
- semi-automatic, or
- automatic

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3.3.1 Accuracy

A zero-setting device shall permit setting the indication to zero with a deviation of not more than $\pm 0.25 d$.

3.3.2 Maximum effect

The effect of any zero-setting device shall not alter the maximum weighing capacity of the instrument.

The overall effect of zero-setting and zero-tracking devices shall not be more than 4 %, and of the initial zero-setting device not more than 20 %, of the maximum capacity.

3.3.3 Control of the zero-setting devices

An instrument whether or not equipped with an initial zero-setting device, may have a combined semi-automatic zero-setting and semi-automatic tare-balancing device operated by the same key.

If an instrument has a zero-setting device and a tare-weighing device the control of the zero-setting device shall be separate from that of the tare-weighing device.

A semi-automatic zero-setting device shall function only:

- when the instrument is in stable equilibrium (3.5.1),
- if it cancels any previous tare operation.

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A non-automatic or semi-automatic zero-setting device shall not be operable during automatic operation.

3.3.4 Automatic zero-setting device

An automatic zero-setting device may operate at the start of automatic operation, as part of every automatic weighing cycle, or after a programmable time interval. A description of the operation of the automatic zero-setting device (e.g. the maximum programmable time interval) shall be included in the type approval certificate.

The automatic zero-setting device shall operate:

- only when the stability criteria (3.5.1) are fulfilled, and

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- sufficiently often to ensure that zero is maintained within $0.5 d$.

Where the automatic zero-setting device operates as part of every automatic weighing cycle, it shall not be possible to disable this device or to set this device to operate at time intervals.

Where the automatic zero-setting device operates after a programmable time interval, the manufacturer shall specify the maximum time interval.

The maximum programmable time interval for automatic zero-setting required above may start again after zero tracking has taken place.

The actual maximum programmable time interval for automatic zero-setting shall be specified considering the actual operating conditions of the instrument. The automatic zero-setting device shall either automatically set to zero after the allocated time or should stop the instrument so that a zero-setting operation can occur or be capable of generating information to draw attention to overdue zero setting.

3.3.5 Zero-tracking device

A zero-tracking device shall operate only when:

- the indication is at zero, and
- the stability criteria (3.5.1) are fulfilled, and
- the corrections are not more than $0.5 d$ per second.

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When zero is indicated after a tare operation, the zero-tracking device may operate within a range of 4 % of Max around the actual zero.

- Notes:
- (1) Zero-tracking is functionally similar to automatic zero-setting. The differences are important in applying the requirements of 3.5. Refer to T.2.6.1 and T.2.6.2. Zero-tracking may operate continuously (when the conditions of 3.3.5 are fulfilled) and must therefore be subject to a maximum rate of correction ($0.5 d/\text{second}$) to prevent interaction with the normal weighing process.
 - (2) Automatic zero-setting is activated by an event, such as part of every automatic weighing cycle or after a programmed interval. The maximum rate of correction applicable to zero-tracking does not apply to zero-setting.

3.4 Indication and printing of weighing results

3.4.1 Quality of indication

The mass indication shall be the self-indicating type. Reading of the results shall be reliable, easy and unambiguous under conditions of normal use:

- the overall inaccuracy of reading of an analogue indicating device shall not exceed $0.2 d$,
- the figures forming the results shall be of a size, shape and clarity for reading to be easy.

The scales, numbering and printing shall allow reliable, simple and unambiguous reading of the results by simple juxtaposition and shall bear the name or symbol of the appropriate unit of mass.

3.4.2 Form of the indication

Weighing results shall contain the names or symbols of the units of mass in which they are expressed.

For any one indication of mass, only one unit of mass may be used.

The scale intervals of the indicating or printing devices shall be in the form of 1×10^k , 2×10^k or 5×10^k , "k" being a positive or negative whole number or zero.

All indicating, printing and tare weighing devices of an instrument shall, within any one weighing range, have the same scale interval for any given load.

A digital indication shall display at least one figure beginning at the extreme right.

A decimal fraction shall be separated from its integer by a decimal sign (comma or dot), with the indication showing at least one figure to the left of the sign and all figures to the right.

Zero may be indicated by one zero to the extreme right, without a decimal sign.

The unit of mass shall be chosen so that the values have not more than one non-significant zero to the right. For values with decimal sign, the non-significant zero is allowed only in the third position after the decimal sign. The units of mass shall be written in small letters (lower case) as indicated in 2.8.

3.4.3 Limits of indication

WIM instruments shall not indicate or print the mass of any wagon, or train that will cause a weighing result less than Min or greater than $\text{Max} + 9 d$ without giving a clear warning on the indication and/or the printout.

3.4.4 Single axle or bogie mass

Single axle or bogie mass shall not be indicated or printed without an associated warning that these weighing results cannot be verified.

3.4.5 Operating speed

WIM instruments shall not print the mass of any wagon that has travelled over the load receptor at a speed outside the range of operating speeds. An appropriate indication shall be included on the printout for any wagon mass not printed and a subtotal may be printed exclusive of unweighed wagons provided that an indication clearly specifies that it is not the train mass.

3.4.6 Roll back

The mass indication and printout shall not be altered due to any part of any wagon travelling over the load receptor more than once.

3.4.7 Totalising device

A WIM instrument shall be provided with a totalising device which totalises the mass of the individual wagons to provide a totalised mass. Operation of this device may be automatic, in which case the instrument shall be provided with a vehicle recognition device, or semi-automatic (operates automatically following a manual command).

3.4.8 Vehicle recognition device

A WIM instrument shall be provided with a vehicle recognition device when the wagon mass is indicated or printed automatically following a weighing operation. The device shall detect the presence of a wagon in the weigh zone and shall detect when the whole wagon has been weighed.

3.4.9 Vehicle guide device

A WIM instrument shall not indicate or print the wagon mass if any part of the wagon did not pass fully over the load receptor. Alternatively, a lateral guide system may be used to ensure that all the wheels of the wagon pass fully over the load receptor.

If only one direction of travel is specified for a WIM instrument, an error message shall be given or the instrument shall not indicate or print the wagon mass if it travels in the wrong direction.

3.4.10 Indication or printout of weight for normal operation

For normal operation the scale interval of indications or printouts of individual wagon mass shall be the scale interval d .

The scale interval of indications or printouts of the mean (systematic) error for a number of consecutive automatic weighings of a wagon or single-axle, may be to a higher resolution than the scale interval d .

The minimum printout resulting from each normal weighing operation shall be the date and the time, the operating speed, and in the case of wagon weighing each wagon mass and in the case of train weighing the train mass.

For partial weighing of two-axle wagons, the minimum printout shall include the single-axle mass and number of axles (where applicable)

3.5 Digital indicating and printing devices

The following requirements apply in addition to those in 3.4.1 through 3.4.10

3.5.1 Stable equilibrium

An indication is defined as being in stable equilibrium if it is sufficiently close to the final weighing value.

Stable equilibrium is considered to be achieved if:

- in case of printing and/or data storage, the printed or stored weighing values do not deviate more than 1 d from the final weighing value (i.e. two adjacent values are allowed).
- in case of zero or tare operations, a correct operation according to 3.3.3, 3.3.4, 3.3.5, 3.5.2 and 3.6 of the device within relevant accuracy requirements is achieved.

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Both conditions shall also be met under continuous or temporary disturbance of the equilibrium.

For instruments that weigh dynamically no separate criteria for stable equilibrium are given.

3.5.2 Printing device

Printing shall be clear and permanent for the intended use. Printed figures shall be at least 2 mm high.

If printing takes place, the name or the symbol of the unit of measurement shall be either to the right of the value or above a column of values.

Printing shall be inhibited if the stability criteria (3.5.1) are not fulfilled.

3.6 Memory storage device

The primary indications may be stored in a memory of the instrument for subsequent indication, printing, data transfer, totalising, etc. The storage of primary indications shall be inhibited if the stability criteria (3.5.1) are not fulfilled.

3.7 Integral control instrument

If the WIM instrument under test is to be used as an integral control instrument, for the purposes of determining the wagon mass, it shall meet the requirements of 3.7.1 to 3.7.4 inclusive, and 6.1.

3.7.1 Zero-setting

The instrument shall permit setting the indication to zero with a deviation of not more than ± 0.25 of the scale interval for a stationary load (2.4).

3.7.2 Eccentric loading

The indications for different positions of the load shall comply with the maximum permissible errors in 2.2.1 for the given load.

3.7.3 Discrimination

An additional load that is equal to 1.4 times the scale interval for a stationary load, when gently placed on or withdrawn from each load receptor in turn when at equilibrium at any load shall change the initial indication.

3.7.4 Repeatability

The difference between the results of several weighings of the same load shall not be greater than the absolute value of the maximum permissible error of the instrument for that load.

3.8 Installation

3.8.1 General

WIM instruments shall be manufactured and installed so as to minimise any adverse effects of the installation environment. The space between the weighing instrument and ground shall allow all covered parts of the load receptor to be kept free from all debris or other matter that could affect the accuracy of the instrument. Where particular details of installation have an effect on the weighing operation (e.g. site levels, length of aprons), these details shall be recorded in the test report.

Further installation information is provided in Annexe C.

3.8.2 Composition

WIM instruments shall include the following:

- one or more load receptors;
- aprons;
- vehicle-type identification devices (e.g. track switches, load cells, transponder, etc);
- indicating device;
- printer;
- control unit.

3.8.3 Ease of static testing

The instrument shall be accessible to vehicles for moving test weights if it is to be used as the control instrument.

3.8.4 Drainage

If the weighing mechanism is contained in a pit, there shall be a provision for drainage to ensure that no portion of the instrument becomes submerged or partially submerged in water or any other liquid.

3.8.5 Heating

If the weighing mechanism is installed in environment with temperatures of - 10 °C or less, there shall be provision for heating (i.e. heater cable) to ensure that the modules operate within the operating conditions specified by the manufacturer.

3.9 Software

The metrologically relevant software used in a WIM instrument must be present in such a form in the instrument that alteration of the software is not possible without breaking a seal, or any change in the software can be signalled automatically by means of an identification code.

The software shall be assigned with a fixed version number. This version number shall be adapted in the case of every software change that may affect the functions and accuracy of the WIM instrument.

For WIM instruments and modules with embedded software, the manufacturer shall describe or declare that the software of the instrument or module is embedded, i.e., it is used in a fixed hardware and software environment and cannot be modified or uploaded via any interface or by other means after securing and/or verification. In addition to the documentation required in 5.1.1 the manufacturer shall submit the following documentation:

- Description of the metrologically relevant functions
- Software identification that is clearly assigned to the metrologically relevant functions
- Securing measures foreseen to provide for evidence of an intervention

The software identification shall be provided by the instrument and listed in the type approval certificate.

3.10 Securing (sealing) of components, interfaces and pre-set controls

3.10.1 General

Components, interfaces, software devices and pre-set controls that are not intended to be adjusted or removed by the user shall be fitted with a sealing device or shall be enclosed. When enclosed, it shall be possible to seal the enclosure. However, other types of sealing are permitted which provide sufficient integrity, e.g. electronic seals.

The seals should, in all cases, be easily accessible. Sealing should be provided on all parts of the measuring system which cannot be materially protected in any other way against operations liable to affect the measurement accuracy.

Any device for changing the parameters of measurement results, particularly for correction and calibration, shall be sealed.

3.10.2 Electronic sealing devices

When access to parameters that participate in the determination of results of measurement is not protected by mechanical sealing devices, the protection shall fulfil the following provisions:

- a) access shall only be allowed to authorised people, e.g. by means of a code (key-word) or of a special device (hard key, etc); the code must be changeable;
- b) it shall be possible for at least the last intervention to be memorised and it must be possible to access and display this information; the record shall include the date and a means of identifying the authorised person making the intervention (see (a) above); the traceability of the last intervention shall be assured for at least two years, if it is not overwritten on the occasion of a further intervention; if it is possible to memorise more than one intervention, and if deletion of a previous intervention must occur to permit a new record, the oldest record shall be deleted.

3.10.3 Adjustment

A WIM instrument may be fitted with an automatic or a semi-automatic span adjustment device. This device shall be incorporated inside the instrument. External influence upon this device shall be practically impossible after **securing**.

3.11 Descriptive markings

Instruments shall bear the following basic markings at each location having a mass indicating or printing device.

3.11.1 Markings shown in full

- identification mark of the manufacturer
- identification mark of the importer (if applicable)
- designation of the instrument
- serial number of the instrument (on each load receptor, if applicable)
- weighing method (see T.3.1)
- maximum wagon mass *kg or t*
- minimum wagon mass *kg or t*
- not to be used to weigh liquid products (if applicable)
- full draught or number of partial weighings per wagon
- maximum transit speed *km/h*
- direction of weighing (if applicable)
- wagons pushed/pulled (whichever is applicable)
- scale interval for stationary load (if applicable) *kg or t*
- electric power supply voltage *V*
- electric power supply frequency *Hz*
- Temperature range (when not -10°C to 40°C)

3.11.2 Markings shown in code

3.11.2.1 For all WIM instruments

- type approval sign in accordance with national requirements
- accuracy class wagon mass (each weighing method, if applicable) *0.2, 0.5, 1 or 2*
- accuracy class total mass *A, B, C or D*
- maximum capacity *Max = kg or t*
- minimum capacity *Min = kg or t*
- scale interval *d = kg or t*
- maximum operating speed *s_{max} = km/h*
- minimum operating speed *s_{min} = km/h*

3.11.2.2 For train weighing

Markings required for each weighing method applicable:

- maximum number of wagons per train $n_{max} = \dots\dots$
- minimum number of wagons per train $n_{min} = \dots\dots$

3.11.3 Supplementary markings

Depending upon the particular use of the instrument, one or more supplementary markings may be required on type approval by the metrological authority issuing the type approval certificate.

3.11.4 Other markings

The designation of the liquid(s) which the instrument is designed to weigh (if applicable).

3.11.5 Presentation of descriptive markings

Descriptive markings shall be indelible and of a size, shape and clarity that permit legibility under normal conditions of use of the instrument.

Descriptive markings may be shown in an official language in accordance with national regulation.

Markings shall be grouped together in a clearly visible place on the instrument, either on a descriptive plate fixed near the indicating device or on the indicating device itself.

It shall be possible to seal the plate bearing the markings, unless it cannot be removed without being destroyed.

The descriptive markings may be shown on a programmable display which is controlled by software. In this case, means shall be provided for any access to reprogramming of the markings to be automatically and non-erasably recorded and made evident by an audit trail, e.g. by traceable access software such as an event logger providing a record of the changes.

When a programmable display is used, the plate of the instrument shall bear at least the following markings:

- type and designation of the instrument,
- name or identification mark of the manufacturer,
- type approval number,
- electrical supply voltage,
- electrical supply frequency,
- pneumatic/hydraulic pressure, (if applicable).

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3.12 Verification marks

3.12.1 Position

Instruments shall have a place for the application of verification marks. The following applies for this place:

- the part on which the marks are located cannot be removed from the instrument without damaging the marks;
- the place shall permit the easy application of the marks without changing the metrological qualities of the instrument;
- the marks shall be visible when the instrument is in service.

3.12.2 Mounting

Instruments required to bear verification marks shall have a verification mark support located as specified above, which shall ensure the conservation of the marks as follows:

- when the mark is made with a stamp, the support may consist of a strip of lead or any other material with similar qualities inserted into a plate fixed to the instrument or a cavity bored into the instrument;
- when the mark consists of an adhesive transfer, a space shall be provided for this purpose.

4 REQUIREMENTS FOR ELECTRONIC INSTRUMENTS

Electronic instruments shall comply with the following requirements, in addition to the applicable requirements of all other clauses.

4.1 General requirements

4.1.1 Rated operating conditions

Electronic weighing instruments shall be designed and manufactured so that they do not exceed the maximum permissible errors under rated operating conditions.

4.1.2 Disturbances

Electronic instruments shall be designed and manufactured so that when they are exposed to disturbances, either:

- a) significant faults do not occur, or
- b) significant faults are detected and acted upon.

Note: A fault equal to or less than the value specified in T.4.2.7 (1 d) is allowed irrespective of the value of the error of indication.

4.1.3 Durability

The requirements in 4.1.1 and 4.1.2 shall be met durably in accordance with the intended use of the instrument.

4.1.4 Evaluation for compliance

A type of an electronic instrument is presumed to comply with the requirements in 4.1.1, 4.1.2, and 4.1.3 if it passes the examination and tests specified in Annex A.

4.2 Application

4.2.1 The requirements in 4.1.2 may be applied separately to the following:

- a) each individual cause of significant fault, and/or
- b) each part of the electronic instrument.

The choice as to whether to apply 4.1.2 (a) or (b) is left to the manufacturer.

4.3 Functional requirements

4.3.1 Acting upon a significant fault

When a significant fault has been detected, a visual or audible indication shall be provided and shall continue until the user takes action or the fault disappears. Means shall be provided to retain any totalized load information contained in the instrument when a significant fault occurs.

4.3.2 Switch-on procedure

Upon switch-on (in the case of electronic instruments permanently connected to the mains at switch-on of indication), a special procedure shall be performed that indicates all the relevant signs of the indicator in their active and non-active states for a sufficient time to be easily observed by the operator. **This is not applicable for non-segmented displays, on which failures become evident, for example screen-displays, matrix-displays, etc.**

4.3.3 Influence factors

An electronic instrument shall comply with the requirements of 2.7, and in addition it shall maintain its metrological and technical characteristics at:

- (a) relative humidity of 85 % at the upper limit of the temperature range for non-condensation environments, or
- (b) relative humidity of above 93 % when combined with cyclic temperature changes and condensation.

Note: The requirement in (b) is applicable to cases where condensation is important or when the instrument is to be installed in high cyclic temperature environments.

4.3.4 Warm-up time

During the warm-up time of an electronic instrument, there shall be no indication or transmission of the weighing result and automatic operation shall be inhibited.

4.3.5 Interface

An instrument may be equipped with an interface permitting the coupling of the instrument to external equipment. When an interface is used, the instrument shall continue to function correctly and its metrological functions shall not be influenced.

Additionally, functions that are performed or initiated via an interface shall meet the relevant requirements and conditions of Clause 3.

Note: An “interface” comprises all mechanical, electrical and software devices at the data interchange point between an instrument and peripheral devices or other instruments.

It shall not be possible to introduce into an instrument, through an interface, instructions, software programs or data intended or suitable to:

- Display data that are not clearly defined and could be mistaken for a weighing result,
- Falsify displayed, processed or stored weighing results,
- Adjust the instrument or change any adjustment factor.

An interface through which the functions mentioned above cannot be performed or initiated, need not be secured. Other interfaces shall be secured as per 3.10.1.

Functions that are performed or initiated via an interface shall meet the relevant requirements and conditions of clause 4.

An interface intended to be connected to a peripheral device to which the requirements of this Recommendation apply, shall transmit data relating to primary indications in such a manner that the peripheral device can meet the requirements.

4.3.6 Mains power supply (AC)

An instrument that operates from the mains shall, in the event of a power failure, retain the metrological information contained in the instrument at the time of failure for at least 24 hours. A switch-over to an emergency power supply shall not cause a significant fault.

4.3.7 DC mains or battery power supply

An instrument that operates from DC mains or a battery power supply shall, whenever the voltage drops below the manufacturer's specified value, either continue to function correctly or automatically be put out of service.

4.4 Examination and tests

The examination and testing of an electronic weighing instrument is intended to verify compliance with the applicable requirements of this Recommendation and especially with the requirements in Clause 4.

4.4.1 Examinations

An electronic weighing instrument shall be examined to obtain a general appraisal of the design and construction.

4.4.2 Performance tests

An electronic weighing instrument or electronic device, as appropriate, shall be tested as specified in the Annex to determine their correct functioning.

Tests are to be conducted on the whole instrument except when the size and/or configuration of the instrument does not lend itself to testing as a unit. In such cases, the separate electronic devices shall be subjected to testing. It is not intended that electronic devices be further dismantled for separate testing of components. In addition, an examination shall be carried out on the fully operational weighing instrument or, if necessary, on the electronic devices in a simulated set-up that sufficiently represents the weighing instrument. The equipment shall continue to function correctly as specified in Annex A.

4.4.3 Span stability tests

The instrument shall be subjected to span stability tests at various intervals, before during and after being subjected to performance tests.

When the instrument is subjected to the span stability test specified in A.8:

- the maximum allowable variation in the errors of indication shall not exceed half the absolute value of the maximum permissible error in 2.2.2 Table 2 for the test load applied on any of the n measurements;
- where the differences of the results indicate a trend more than half the allowable variation specified above, the test shall be continued until the trend comes to rest or reverses itself, or until the error exceeds the maximum allowable variation.

5 METROLOGICAL CONTROLS

The metrological controls of instruments shall, in agreement with national legislation, consist of the following:

- type evaluation;
- initial verification;
- subsequent verification
- in-service inspection.

Tests should be applied uniformly by the legal metrology services and should form a uniform program. Guidance for the conduct of type evaluation and initial verification is provided in OIML International Documents D 19 Bibliography [4] and D 20 Bibliography [5] respectively.

5.1 Type evaluation

5.1.1 Documentation

The application for type evaluation shall include documentation which provides the following information:

- metrological characteristics of the instrument;
- a standard set of specifications for the instrument;
- a functional description of the components and devices;
- drawings, diagrams and general software information (if applicable), explaining the construction and operation;
- any document or other evidence demonstrating that the design and construction of the instrument complies with the requirements of this Recommendation.

5.1.2 General requirements

Type evaluation shall be carried out on at least one and normally, not more than three instruments that represent the definitive type. At least one of the instruments shall be completely installed at a typical site and at least one of the instruments or the major component of an instrument shall be submitted in a form suitable for simulation testing in a laboratory. Influence factors shall be applied during simulation tests in a manner that will reveal an alteration of the weighing result for any weighing process to which the instrument could be applied. The evaluation shall consist of the tests specified in 5.1.3.

5.1.3 Type evaluation tests

The submitted documents shall be examined and tests carried out to verify that the WIM instruments comply with the:

- a) the metrological requirements in Clause 2, particularly with reference to maximum permissible errors and, if appropriate, when the instrument is operated in accordance with the manufacturer's specifications for products;
- b) the technical requirements in Clause 3.

c) electronic instruments shall comply with the requirements in Clause 4.

The appropriate metrological authority shall:

- conduct the tests in a manner which prevents an unnecessary commitment of resources;
- permit the results of these tests to be assessed for initial verification when the same instrument is involved;
- ensure that an instrument that can be operated as a non-automatic weighing instrument meets the relevant requirements of OIML R 76-1 Bibliography [3] for Class III or Class IIII instruments.

Note: The appropriate metrological authority is advised to accept, with the consent of the applicant, test data obtained from other metrological authorities without repeating the tests.

5.1.3.1 Modules

Subject to agreement with the metrological authority, the manufacturer may define and submit modules to be examined separately. This is particularly relevant in the following cases:

- where testing the instrument as a whole is difficult or impossible,
- where modules are manufactured and/or placed on the market as separate units to be incorporated in a complete instrument,
- where the applicant wants to have a variety of modules included in the approved type.

5.1.3.1.1 Apportioning of errors

Where it is necessary to separately test modules of an instrument or system the following requirements apply.

The error limits applicable to a module which is examined separately are equal to a fraction p_i of the maximum permissible errors or the allowed variations of the indication of the complete instrument. The fractions for any module have to be taken for the same accuracy class as for the complete instrument incorporating the module.

The fractions p_i shall satisfy the following equation:

$$p_1^2 + p_2^2 + p_3^2 + \dots \leq 1$$

The fraction p_i shall be chosen by the manufacturer of the module and shall be verified by an appropriate test. However, the fraction shall not exceed 0.8 and shall not be less than 0.3, when more than one module contributes to the effect in question.

If the metrological characteristics of the load cell or other major component have been evaluated in accordance with the requirements of OIML R 60 Bibliography [2] or any other applicable Recommendation, that evaluation shall be used to aid type evaluation if so requested by the applicant.

Note: Since the requirements of this clause apply only to the instrument submitted for type evaluation and not to those subsequently submitted for verification, the means used to

determine if the appropriate maximum permissible error or maximum allowable deviation has been exceeded will be decided and mutually agreed upon between the metrological authority and the applicant. Following are examples of these means:

- an adaptation of an indicating device or printer to give greater resolution than that of the scale interval;
- the use of the scale interval for stationary load;
- the use of weights of $1/10 d$ to determine the changeover point;
- any other means mutually agreed upon.

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5.1.3.2 In-motion tests for type approval

The instrument or modules shall be tested in accordance with the specifications in Clause 6, using the reference wagons specified in 6.4, under the rated operating conditions in accordance with the type specification. The errors shall be determined as specified in 5.1.3.3.

5.1.3.2 Evaluation of errors for automatic weighing

5.1.3.2.1 Single (uncoupled) wagon weighing

The error for automatic weighing shall be the indicated mass of the reference wagon observed and recorded (6.7) as appropriate, minus the conventional true value of the reference wagon mass (6.6) as appropriate. The MPE shall be as specified in 2.2.1.1 for initial verification and as appropriate for the accuracy class of the instrument.

5.1.3.2.2 Coupled wagon or train weighing

The error for automatic weighing shall be the mass of the train inclusive of all indicated mass of the individual reference wagons or coupled reference wagons in the train observed and recorded as appropriate (6.7), minus the conventional true value of the train mass as defined in 6.6 as appropriate. The MPE shall be as specified in either 2.2.1.1 or 2.2.1.2 for initial verification and as appropriate for the class of the instrument.

5.1.4 Provision of means for testing

For the purposes of testing, the applicant may be required to furnish the metrological authority with the test vehicles, material, qualified personnel and a control instrument. The instrument under test may be used as a control instrument provided it complies with the requirements in 6.1.2.

5.1.5 Place of testing

Instruments submitted for type approval may be tested at the following places:

- a site at which all necessary tests can be conducted and agreed upon between the metrological authority and the applicant;
- a laboratory considered appropriate by the metrological authority;
- any other suitable place mutually agreed upon by the metrological authority and the applicant.

5.2 Initial verification

5.2.1 Tests

Instruments shall comply with the requirements in Clause 2 (except 2.7) and Clause 3 for any product(s) for which they are intended and when operated under normal conditions of use.

Tests shall be carried out by the appropriate metrological authority, in-situ, in a normal installation. The instrument shall be installed so that an automatic weighing operation will be virtually the same for testing as it is for a transaction.

The appropriate metrological authority shall conduct the tests in a manner that prevents an unnecessary commitment of resources. In appropriate situations and to avoid duplicating tests previously performed on the instrument for type evaluation under 5.1.3, the authority may use the results of observed tests for initial verification.

5.2.2 In-motion tests for initial verification

In-motion tests shall be conducted:

- in accordance with the descriptive markings (3.11),
- under the rated conditions for which the instrument is intended
- in accordance with the test methods in Clause 6, with the exception that the types of wagons and, for tests with coupled wagons, the number of wagons in the test train shall be in accordance with the normal operation of the instrument.

5.2.3 Evaluation of errors for automatic weighing

The errors for automatic weighing shall be determined as specified in:

- a) 5.1.3.2.1 for single (uncoupled) wagon weighing;
- b) 5.1.3.2.2 for train weighing

5.2.4 Provision of means for testing

For the purposes of testing, the applicant may be required to furnish the metrological authority with the test vehicles, material, qualified personnel and a control instrument. The instrument under test may be used as a control instrument provided it comply with the requirements in 6.1.2.

5.2.5 Place of testing

Initial verification tests shall be conducted entirely at the place of installation and during testing, the instrument shall include all parts which form the assembly as intended for normal use.

5.3 Subsequent verification

Subsequent verification shall be carried out in accordance with the same provisions as in 5.2 for initial verification.

5.4 In-service inspection

In-service inspection shall be carried out in accordance with the same provisions as in 5.2 for initial verification, with the exception that the in-service maximum permissible errors specified in 2.2 shall be applied.

6 TEST METHODS

6.1 Control instrument for full-draught wagon weighing

A control instrument for determining the conventional true value of each reference wagon mass by full-draught weighing shall be available for testing. The control instrument may be either separate or integral.

6.1.1 Separate control instrument

A control instrument, separate from the instrument being tested shall ensure the determination of the conventional true value of each reference wagon mass by full-draught weighing when stationary and uncoupled, to an accuracy of at least one-third of the maximum permissible error for weighing-in-motion specified in 2.2.1.

6.1.2 Integral control instrument (3.7)

The instrument under test may be used as the control instrument provided that it shall:

- have an appropriate scale interval or scale interval for stationary load (2.4);
- comply with the requirements in 3.7;
- ensure the checking of the reference wagon (or test weights) to an accuracy of at least one-third of the maximum permissible error for weighing-in-motion specified in 2.2.1.

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6.1.3 Control instruments for partial weighing of two-axle wagons

An instrument constructed only for partial weighing of two-axle wagons may be used as the control instrument (separate or integral) for determining the conventional true value of the reference wagon mass by individual axle measurement when stationary provided that:

- the alignment correction or exemption test for partial weighing instruments in Annex B has been successfully applied.
- it ensures the determination of the conventional true value of the static two-axle reference wagon mass to an error not greater than one-third of whichever is the smaller of the appropriate MPE for in-motion tests in 2.2.1.

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6.2 Static weighing test for integral control instruments

This test is applicable if the WIM instrument being verified is to be used as the control instrument for measuring the static reference wagon mass.

6.2.1 Test weights

Errors shall be determined for test weights of:

- zero;
- minimum capacity;
- maximum capacity;
- at or near a load where the maximum permissible error changes.

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6.2.2 Distribution of test weights

Except for eccentricity tests, standard weights shall be evenly distributed on the load receptor.

6.2.3 Multiple load receptors

Each load receptor shall be tested by the static-weighing method both independently and in combination.

6.2.4 Eccentricity tests

Tests shall be carried out without excessive stacking or overlapping of the weights on the load receptor provided that the conditions are practical and safe.

On installations where the weighed length is very short it may not be possible to apply this test fully. If so note the reduced load.

6.3 Standard weights

The error of the standard test weights used for in-motion tests shall not be greater than one-third of the maximum permissible error for the load, as specified in Table 3 for initial verification.

6.3.1 Substitution of standard test weights at verification

When testing instruments with $\text{Max} > 1 t$, instead of standard test weights any other constant mass may be used, provided that standard test weights of at least $1 t$ or 50 % of Max, whichever is greater, are used. Instead of 50 % of Max, the portion of standard test weights may be reduced to:

- 35% of Max if the repeatability error is $\leq 0.3 d$,
- 20% of Max if the repeatability error is $\leq 0.2 d$.

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The repeatability error has to be determined with a load of about the value where the substitution is made, by placing it 3 times on the load receptor.

6.4 Reference wagons

The reference wagons to be used for testing shall represent the range of wagons available in the appropriate Member State and for which the instrument is intended. The reference wagons shall be selected to cover, as far as practicable, the weighing range for which the instrument is approved.

Where a particular instrument is tested using a limited range of wagon types this should be noted in the OIML certificate.

Wagons carrying liquid loads or other products that that may be subjected to fluctuations in its gravity centre when the wagon moves, shall be used as reference wagons only if the WIM instrument will be applied subsequently for determining the mass of such wagons. If the WIM instrument is not intended for this use, it shall bear the marking “not to be used to weigh wagons carrying liquids or other products that that may be subjected to fluctuations in its gravity centre with vehicle movement”

6.4.1 Single (uncoupled) wagon

A minimum of five single reference wagons with a range of loads from zero-load (unloaded) to a fully loaded wagon shall be used for assessing compliance with the requirements in 5.1.3.2.

6.4.2 Coupled wagon or train weighing

A minimum of five (and normally not more than fifteen) reference wagons in a test train. There shall be two test trains, one containing empty reference wagons and the other containing full and partially loaded reference wagons. Each test train shall be weighed repeatedly and in each direction (if applicable) to yield not less than 60 wagon mass indications or the equivalent in total train mass.

The proportion of reference wagons to the remaining wagons in a test train shall be in accordance with Table 4.

Table 4 Proportion of reference wagons in a test train	
Total number of wagons in test train (n)	Minimum number of reference wagons
$< n \leq 10$	n
$10 < n \leq 30$	10
$30 < n$	15

If the number of reference wagons is less than the total number of wagons in a test train, the reference wagons shall be distributed throughout the train.

6.5 Number of in-motion tests

Each reference wagon shall undergo a minimum of five test runs conducted at operating speeds (T.5) that are within the range of speeds for which the instrument is be evaluated.

6.6 Conventional true value of the reference wagons mass

The conventional true value of each reference wagon mass shall be determined by full draught weighing on a suitable control instrument, as detailed in A.9.3.1.2.

6.7 Indicated reference wagon mass

The indication or printout of the reference wagon mass following an automatic weighing operation shall be observed and recorded. Where possible, the procedures of A.3.6.1 and A.3.6.2 shall be used to eliminate the rounding errors included in any digital indication and measurement of the weighing results.

6.8 Mean values of the reference wagon mass

The mean value for a reference wagon mass shall be the sum of the indicated or printed mass values obtained for a reference wagon during an in-motion test, divided by the number of values for that reference wagon.

ANNEX A (Mandatory)

TEST PROCEDURES FOR AUTOMATIC RAIL-WEIGHBRIDGES

Meaning of symbols:

I	=	<i>Indication</i>
L	=	<i>Load</i>
ΔL	=	<i>Additional load to next changeover point</i>
P	=	$I + \frac{1}{2}d - \Delta L$ = <i>indication prior to rounding</i>
P_n	=	<i>nth indication prior to rounding</i>
d	=	<i>Scale interval</i>
E	=	$P - L$ = <i>error</i>
E_0	=	<i>Error calculated at zero</i>
E_c	=	<i>Corrected error</i>
$E\%$	=	$(P - L)/L$ %
MPE	=	<i>Maximum permissible error</i>
MPD	=	<i>Maximum permissible deviation</i>
EUT	=	<i>Equipment Under Test</i>
Max	=	<i>Maximum capacity</i>
Min	=	<i>Minimum capacity</i>
p_i	=	<i>A fraction of the maximum permissible errors applicable to a part of the complete instrument which is examined separately.</i>

A.1 EXAMINATION FOR TYPE APPROVAL

A.1.1 Documentation (5.1.1)

Review the documentation that is submitted, including necessary photographs, drawings, diagrams, general software information, relevant technical and functional description of main components, devices etc. to determine if it is adequate and correct. Consider the operational manual.

A.1.2 Comparing construction with documentation (5.1.1)

Examine the various devices of the instrument to ensure compliance with the documentation.

A.1.3 Technical requirements (3)

Examine the instrument for conformity with the technical requirements according to the checklist given in OIML R 106-2, the test report format.

A.1.4 Functional requirements (4.3 and 4.4)

Examine the instrument for conformity with the functional requirements according to the checklist given in OIML R 106-2, the test report format.

A.2 EXAMINATION FOR INITIAL VERIFICATION

A.2.1 Compare construction with documentation (5.2)

Examine the instrument for conformity with the approved type.

A.2.2 Metrological characteristics

Note metrological characteristics according to the checklist given in OIML R 106-2, the test report format.

A.2.3 Descriptive markings (3.11)

Check the descriptive markings according to the type approval.

A.2.4 Verification marks (3.12) and sealing devices (3.10)

Check the arrangements for verification marks and sealing according to the checklist given in OIML R 106-2, the test report format.

A.3 GENERAL TEST REQUIREMENTS

A.3.1 Power supply

Power-up the equipment under test (EUT) for a time period equal to or greater than the warm-up time specified by the manufacturer and maintain the EUT energised for the duration of each test.

A.3.2 Zero-setting

Adjust the EUT as closely as practicable to zero prior to each test, and do not readjust it at any time during the test, except to reset it if a significant fault has been indicated.

Certain tests require the automatic zero-setting and zero-tracking devices to be in operation (or not in operation). Where there is no specific requirement to this effect, the automatic zero-setting and zero-tracking devices shall be switched-off. When this is done it shall be mentioned in the test report.

A.3.3 Temperature

The tests shall be performed at a steady ambient temperature, usually normal room temperature unless otherwise specified. The temperature is deemed to be steady when the difference between the extreme temperatures noted during the test does not exceed one-fifth of the temperature range of the instrument without being greater than 5 °C and the rate of change does not exceed 5 °C per hour. Note that this requirement does not apply to in-motion tests.

The handling of the instrument shall be such that no condensation of water occurs on the instrument.

A.3.4 Recovery

After each test, allow the instrument to recover sufficiently before the following test.

A.3.5 Preloading

Before each weighing test the instrument shall be pre-loaded to Max, except for the tests in A.6.1 and A.7.2.2.

A.3.6 Evaluation of error in non-automatic (static) operation

A.3.6.1 Indication with a scale interval smaller than d

If an instrument with digital indication has a device for displaying the indication with a smaller scale interval than d (e.g. $\leq 0.2 d$), this device may be used to calculate the error. If a device is used it should be noted in the test report.

A.3.6.2 Use of standard test weights to assess rounding error

Where necessary, standard test weights meeting the requirements of 6.3 may be used to assess the rounding error.

A.3.6.2.1 General method to assess error prior to rounding

For instruments with digital indication having a scale interval d , changeover points may be used to interpolate between scale intervals, i.e. to determine the indication of the instrument, prior to rounding, as follows:

At a certain load, L , the indicated value, I , is noted. Additional weights of about $0.1 d$ are successively added until the indication of the instrument is increased unambiguously by one scale interval ($I + d$). The additional load ΔL added to the load receptor gives the indication, P , prior to rounding by using the following formula:

$$P = I + 0.5 d - \Delta L$$

The error prior to rounding is:

$$E = P - L = I + 0.5 d - \Delta L - L$$

Example: an instrument with a scale interval, d , of 10 kg is loaded with 1000 kg and thereby indicates 1000 kg. After adding successive weights of 1 kg, the indication changes from 1000 kg to 1010 kg at an additional load of 3 kg. Inserted in the above formula these observations give:

$$P = (1000 + 5 - 3) \text{ kg} = 1002 \text{ kg}$$

Thus the true indication prior to rounding is 1002 kg, and the error is:

$$E = (1002 - 1000) \text{ kg} = 2 \text{ kg}$$

A.3.6.2.2 Correction for error at zero

Evaluate the error at zero load, (E_0) by the method of A.3.6.2.1.

Evaluate the error at load L , (E) by the method of A.3.6.2.1.

The corrected error prior to rounding, (E_c) is:

$$E_c = E - E_0$$

Example: if, for the example in A.3.5.2.1, the error calculated at zero load was:

$$E_0 = + 1 \text{ kg},$$

The corrected error is:

$$E_c = + 2 - (+ 1) = + 1 \text{ kg}$$

A.4 TEST PROGRAM

A.4.1 Type evaluation (5.1)

Clauses A.1, and A.6 to A.9 shall normally be applied for type evaluation.

Sub-clause A.5.2 may be omitted if the WIM instrument under test is not an integral control instrument.

The tests for clauses A.6 to A.8 shall be performed with static load, a wheel movement simulator (switches) may be used if necessary for the calculation of the weighing results.

A.4.2 Initial verification (5.2)

Clauses A.2 and A.9 shall be applied for initial verification.

If the WIM instrument under test is to be used as an integral control instrument the tests in Sub-clause A.5.2 shall also be applied.

The test shall include all dynamic in-motion effects corresponding to normal operation of the instrument.

A.5 PERFORMANCE TESTS DURING TYPE EVALUATION

A.5.1 Zero-setting (3.3)

A.5.1.1 Range of zero-setting

A.5.1.1.1 Initial zero-setting

(a) Positive range

With the load receptor empty, set the instrument to zero. Place a test weight on the load receptor and switch the instrument off and then back on. Continue this process until, after placing weights on the load receptor and switching the instrument off and on, it does not reset to zero. The maximum weight that can be re-zeroed is the positive portion of the initial zero-setting range.

(b) Negative range

- (1) Remove any weight from the load receptor and set the instrument to zero. Then, if possible, remove any non-essential components (e.g. the platform) of the load receptor. If, at this point, the instrument can be reset to zero by switching it off and back on, the non-essential components (e.g. the mass of the load receptor) is used as the negative portion of the initial zero-setting range.
- (2) If the instrument cannot be reset to zero with the non-essential components removed, add weights to any live part of the scale (e.g. on the parts where the load receptor rests) until the instrument indicates zero again.
- (3) Then remove weights and, after each weight is removed, switch the instrument off and back on. The maximum load that can be removed while the instrument can still be reset to zero by switching it off and on is the negative portion of the initial zero-setting range.
- (4) The initial zero-setting range is the sum of the positive and negative portions.
- (5) Alternatively, if it is not possible to test the negative range of initial zero setting by removing parts of the instrument, the instrument may be temporarily re-adjusted with a test weight applied before proceeding to step (3) above. (The test weight applied for the temporary re-calibration should be greater than the permissible negative portion of the initial zero setting range which can be calculated from the result of the positive range test).
- (6) If it is not possible to test the negative portion of the initial zero-setting range by these methods then only the positive part of the initial zero-setting range need be considered.
- (7) Reassemble or adjust the instrument for normal use after the above tests

A.5.1.1.2 Semi-automatic zero-setting

This test shall not be carried out during the span stability test.

This test is performed in the same manner as described in A.5.1.1.1, except that the zero-setting device is used rather than switching the instrument on and off.

A.5.1.1.3 Automatic zero-setting

This test shall not be carried out during the span stability test.

Remove the non-essential parts (e.g. platform) of the load receptor or re-adjust the instrument as described in A.5.1.1.1 and place weights on the live part of the scale until it indicates zero.

Remove weights in small amounts and after each weight is removed allow the instrument to operate through the appropriate part of the automatic cycle so as to see if the instrument is reset to zero automatically.

The maximum weight that can be removed so the instrument can still be reset to zero is the zero-setting range.

If the load receptor cannot readily be removed, a practical approach can be to add weights to the instrument and use another zero-setting device, if provided, to set the instrument to zero. Then remove weights and check whether the automatic zero-setting still sets the instrument to zero. The maximum weights that can be removed so that the instrument can still be reset to zero is the zero-setting range.

A.5.1.2 Accuracy of zero-setting

A.5.1.2.1 Semi-automatic zero-setting

The accuracy of the zero-setting device is tested by setting the instrument to zero and then determining the additional load at which the indication changes from zero to one scale interval above zero. The error at zero is calculated according to the description in A.3.6.2.1.

A.5.1.2.2 Automatic zero-setting or zero-tracking

The indication is brought outside of the automatic range (e.g. by loading with 10 d). Then the additional load at which the indication changes from one scale interval to the next above is determined and the error is calculated according to the description in A.3.6.2.1. It is assumed that the error at zero load would be equal to the error at the load in question.

A.5.1.3 Setting to zero before loading

For instruments with digital indication, the adjustment to zero or the determination of the zero point is carried out as follows:

- a) for instruments with non-automatic zero-setting, weights equivalent to half a scale interval are placed on the load receptor, and the instrument is adjusted until the indication alternates between zero and one scale interval. Then weights equivalent to half a scale interval are removed from the load receptor to attain a centre of zero reference position;
- b) for instruments with semi-automatic or automatic zero-setting, the deviation from zero is determined as described in A.5.1.2.

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A.5.2 Non-automatic tests of the integral control instrument (3.7)

Note: This sub-clause is only applicable to WIM instruments which are to be used as a control instrument. The tests are performed on the control instrument in-situ at the time of type approval or verification.

A.5.2.1 Zero-setting

A.5.2.1.1 Accuracy of zero-setting (3.7.1)

Determination of the accuracy of zero setting is carried out as described in A.5.1.2.1 or A.5.1.2.2, as appropriate.

A.5.2.2 Determination of weighing performance

A.5.2.2.1 Preloading

Before the first weighing test the instrument shall be preloaded once to Max.

A.5.2.2.2 Static weighing test (6.2)

Apply weights from zero up to and including Max, and then remove the weights back to zero. When determining the initial intrinsic error, at least ten different load values are selected, and for other weighing tests at least five are selected. The values of the loads selected shall include Max and Min, and values at or near those at which the maximum permissible error (MPE) changes.

It should be noted that when loading or unloading weights the load must be respectively increased or decreased in a uniform progression.

Ensure that the error is recorded at each change in load and calculate the errors according to A.3.6.2.1. Record the errors and compare them to the limits in 2.2.2 as appropriate for initial verification.

A.5.2.3 Eccentricity test (3.7.2 and 6.2.4)

Apply weights equal to $1/3$ Max in each half of the load receptor. On an instrument with a load receptor having n points of support with $n > 4$ the fraction $1/(n-1)$ of Max shall applied to each point of support.

The error at each measurement is determined according to A.3.7.1. The zero error E_0 used for the correction is the value determined prior to each measurement.

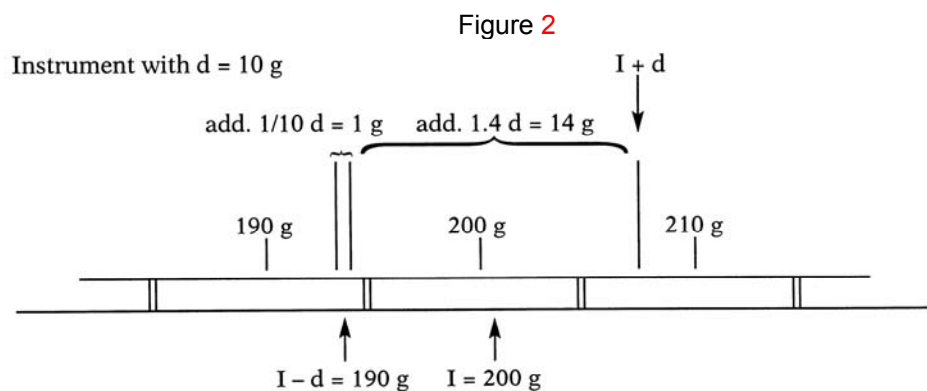
The errors shall not exceed the appropriate maximum permissible errors from 2.2.2 for initial verification.

If the instrument is provided with automatic zero-setting or zero-tracking, it shall not be in operation during the following tests.

A.5.2.4 Discrimination test (3.7.3)

The following tests are performed with three different weights at Min, 0.5 Max and Max.

Sufficient weights (say 10 times $1/10 d$) shall be placed on the load receptor. The weights shall then be removed successively until the indication, I , is decreased unambiguously by one actual scale interval, $I - d$. One of the weights shall be replaced equal to $1.4 d$ on the load receptor to give a result increased by one actual scale interval above the initial indication, $I + d$. See example in Figure 2.



The indication at the start is $I = 200$ g. Remove additional weights until the indication changes to $I - d = 190$ g. Add $1/10 d = 1$ g and thereafter $1.4 d = 14$ g. The indication shall then be $I + d = 210$ g.

A.5.2.5 Repeatability test (3.7.4)

Two series of weighings shall be performed, one with weight of about 50 % and one with weight close to 100 % of Max. Each series shall consist of at least three weighings. Readings shall be taken when the instrument is loaded, and when the unloaded instrument has come to rest between weighings. In the case of a zero deviation between the weighings, the instrument shall be reset to zero, without determining the error at zero. The true zero position need not be determined between the weighings.

If the instrument is provided with automatic zero-setting or zero-tracking, it shall be in operation during the test.

A.6 Additional functionality

A.6.1 Warm-up time test (4.3.4)

This test is to verify that metrological performance is maintained in the period immediately after switch on. The method is to check that automatic operation is inhibited until a stable indication is obtained and to verify that zero and span errors comply with the requirements during the first 30 minutes of operation.

Other test methods which verify that metrological performance is maintained during the first 30 minutes of operation may be used.

- (1) Disconnect the instrument from the power supply for a period of at least 8 hours prior to the test.
- (2) Reconnect the instrument and switch on while observing the indicating device.
- (3) Verify that it is not possible to initiate automatic weighing or printout until the indication has stabilised or until completion of the warm-up time if it is specified by the manufacturer (4.3.4).
- (4) As soon as the indication of the indicating device has stabilised, set the instrument to zero if this is not done automatically
- (5) Determine the error of zero-setting by the method of A.3.6.2.1 and record this error as E_{0i} (error of initial zero-setting) at first and as E_0 when repeating this step.
- (6) Apply a load close to Max. Determine the error by the method of A.3.6.2.1 and A.3.6.2.2.
- (7) Verify that:
 - zero indication error (E_{0i}) is not greater than $0.25 d$ (3.3.1)
 - span error is not greater than the maximum permissible error specified in 2.2.2 for initial verification.
- (8) Repeat stages (5) and (6) after 5, 15 and 30 minutes.
- (9) After each time interval verify that:
 - zero variation error ($E_0 - E_{0i}$) is not greater than $0.25 d \cdot p_i$,
 - span error is not greater than the maximum permissible error specified in 2.2.2 for initial verification.

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A.6.2 Agreement between indicating and printing devices (2.9)

During the course of the tests verify that for the same load, the difference between any two indicating devices having the same scale interval is as follows:

- zero for digital indicating or printing devices;
- not greater than the maximum permissible error for weighing-in-motion for analogue devices.

A.7 INFLUENCE FACTOR AND DISTURBANCE TESTS

A.7.1 Test conditions

A.7.1.1 General requirements

WIM instruments for wagon and train weighing shall comply with the influence factor and disturbance tests conditions and requirements specified in this Annex.

Influence factor and disturbance tests are intended to verify that electronic instruments can perform and function as intended in the environment and under the conditions specified. Each test indicates, where appropriate, the reference condition under which the intrinsic error is determined.

It is not possible to apply these tests to an instrument that is performing an automatic operation. The instrument shall therefore be subjected to the influence factors or disturbances under static conditions or simulated operation as defined herein. The permissible effects of the influence factors or disturbances, under these conditions, are specified for each case.

When the effect of one influence factor is being evaluated, all other factors are to be held relatively constant, at a value close to normal. After each test the instrument shall be allowed to recover sufficiently before the following test.

Where parts of the instrument are examined separately, errors shall be apportioned in accordance with 5.1.3.1.1.

The operational status of the instrument or simulator shall be recorded for each test.

When an instrument is connected in other than a normal configuration, the procedure shall be mutually agreed on by the approving authority and the applicant.

A.7.1.2 Simulator requirements

A.7.1.2.1 General

The simulator for influence factor and disturbance tests should include all electronic devices of the weighing system including a:

- weight simulator;
- train wheel simulator.

A.7.1.2.2 Weight simulator

For practical reasons, the weight simulator may take various forms. For example, it may be a weigh pan or platform scale of approximately $1/1000^{\text{th}}$ of the weight range of a site installation, or a load cell simulator. Whichever method is adopted, it must be independently calibrated and readable to at least $0.1 d$. The simulator must be capable of providing a **minimum input signal, $\mu\text{V}/d$ (normally minimum input voltage) per (scale interval). $\mu\text{V}/d$.**

The weight simulator shall be adequate for train movement simulation and capable of providing the signals from track switches, or other vehicle type identification devices, normally transmitted when a vehicle passes over the weighing system.

A.7.1.2.3 Interfaces (4.3.5)

Susceptibility that would result from the use of electronic interfaces to other equipment shall be simulated in the tests. For this purpose it is sufficient to connect 3 m of interface cable terminated to simulate the interface impedance of the other equipment.

A.7.1.2.4 Documentation

Simulators shall be defined in terms of hardware and functionality by reference to the instrument under test, and by any other documentation necessary to ensure reproducible test conditions. This information shall be attached to, or traceable from, the test report.

A.7.2 Influence factor tests

Summary of tests		
Test	Conditions applied	§
Static temperatures	MPE ^(*)	A.7.2.1
Temperature effect on no load indication	MPE	A.7.2.2
Damp heat tests	MPE	A.7.2.3
AC mains voltage variation	MPE	A.7.2.4
DC mains voltage variation	MPE	A.7.2.5
Internal battery power supply (DC)	MPE	A.7.2.6
Road vehicle 12 V and 24 V battery power	MPE	A.7.2.7

(*) maximum permissible errors as specified in 2.2.2 Table 3

A.7.2.1 Static temperature tests (2.7.1.1)

Static temperature tests are carried out according to basic standard IEC Publication 60068-2-1, Bibliography [6] IEC Publication 60068-2-2, Bibliography [7] and IEC 60068-3-1, Bibliography [8] and according to Table 4.

Table 4 -Static temperature test

Environmental Phenomena	Test specification	Test set-up
Temperature	Reference temperature of 20 °C	IEC 60068-2-2 IEC 60068-2-1 IEC 60068-3-1
	Specified high temperature for 2 hours	
	Specified low temperature for 2 hours	
	Temperature of 5 °C	
	Reference temperature of 20 °C	
Note: Use IEC 60068-3-1 for background information.		

Supplementary information to the IEC test procedures

Object of the test: To verify compliance with the provisions in 2.7.1.1 under conditions of dry heat (non-condensing) and cold.

Test procedures in brief:

Precondition:	16 hours.
Condition of the EUT:	Normal power supplied and "on" for a time period equal to or greater than the warm-up time specified by the manufacturer. Power is to be "on" for the duration of the test.
Stabilization:	2 hours at each temperature under «free air» conditions.
Temperature:	As specified in 2.7.1.1
Temperature sequence:	Reference temperature of 20 °C; Specified high temperature; Specified low temperature; A temperature of 5 °C; Reference temperature of 20 °C.
Number of test cycles:	At least one cycle.
Weighing test:	<p>Adjust the EUT as close to zero indication as practicable prior to the test (if an automatic zero tracking device is connected, adjust it to a value near zero). The EUT shall not be readjusted at any time during the test.</p> <p>After stabilization at the reference temperature and again at each specified temperature, apply at least five different test loads or simulated loads and record:</p> <ul style="list-style-type: none">a) date and time;b) temperature;c) relative humidity;d) test load;e) indications (as applicable);f) errors;g) functional performance.
Maximum allowable variations:	All functions shall operate as designed. All errors shall be within the maximum permissible errors specified in 2.2.2 Table 3.

A.7.2.2 Temperature effect on the no-load indication (2.7.1.2)

No reference to international standards can be given at the present time. This test should therefore be conducted as described below.

This test does not need to be performed for instruments that have automatic zero setting as part of every automatic weighing cycle.

The instrument is set to zero, the temperature is then changed from 20 °C to the prescribed highest and lowest temperature, to 5 °C and to reference 20 °C. After stabilization the error of the zero indication is determined at each temperature level. The change in zero indication per 5 °C is calculated. The changes of these errors are calculated for any two consecutive temperatures of this test.

This test may be performed together with the temperature test (A.7.2.1). The errors at zero shall then be additionally determined immediately before changing to the next temperature and after the 2-hour period after the instrument has reached stability at this temperature.

Note: Pre-loading is not allowed before these measurements.

Automatic zero-setting or zero-tracking if available, shall not be in operation.

Maximum allowable variations: The change in zero indication shall not vary by more than one scale interval for a temperature difference of 5 °C.

Condition of EUT: Normal power «on» for a time period equal to or greater than the warm-up time specified by the manufacturer. Power is to be «on» for the duration of the test.

A.7.2.3 Damp heat tests (4.3.3)

Either the steady-state (A.7.2.3.1) or the cyclic test (A.7.2.3.2) shall be prescribed depending upon the type of the EUT and its application (see 4.2.3).

A.7.2.3.1 Damp heat, steady-state

Damp heat, steady state tests are carried out according to basic standard IEC Publication 60068-2-78, Bibliography [9] and IEC Publication 60068-3-4, Bibliography [10] and according to Table 5.

Table 5 - Damp heat, steady state test

Environmental phenomena	Test specification	Test set-up
Damp heat, Steady state.	Upper limit temperature and relative humidity of 85% for 48 hours.	IEC 60068-2-78 IEC 60068-3-4
Note: Use IEC 60068-3-4 for guidance for damp heat tests.		

Supplementary information to the IEC test procedures

Object of the test: To verify compliance with the provisions in 4.1.1 or 4.1.2 under conditions of high humidity and constant temperature.

Precondition: None required.

Condition of the EUT: Normal power supplied and “on” for a time period equal to or greater than the warm-up time specified by the manufacturer. Power is to be “on” for the duration of the

test. Adjust the EUT as close to zero indication as practicable prior to the test (if an automatic zero tracking device is connected, adjust it to a value near zero). The EUT shall not be readjusted at any time during the test.

The handling of the EUT shall be such that no condensation of water occurs on the EUT.

Stabilization: 3 hours at reference temperature and 50 % humidity;
2 days (48 hours) at the upper limit temperature as specified in 2.7.1.1.

Temperature: Reference temperature of 20 °C and at the upper limit as specified in 2.7.1.1.

Relative humidity: 50 % at reference temperature;
85 % at upper limit temperature.

Temperature-humidity sequence: Reference temperature of 20 °C at 50 % humidity; the upper temperature limit at 85 % humidity; reference temperature of 20 °C at 50 % humidity.

Number of test cycles: At least one cycle.

Weighing test and test sequence: After stabilization of the EUT at reference temperature and 50 % humidity, apply at least five different test loads or simulated loads and record:

- a) date and time;
- b) temperature;
- c) relative humidity;
- d) test load;
- e) indications (as applicable);
- f) errors;
- g) functional performance.

Increase the temperature in the chamber to the upper limit and increase the relative humidity to 85 %. Maintain the EUT at no load for a period of 2 days (48 hours). Following the 2 days, apply at least five test loads and record the data as indicated above. Allow full recovery of the EUT before any other tests are performed.

Maximum allowable variations: All errors shall be within the maximum permissible errors specified in 2.2.2 Table 3.

A.7.2.3.2 Damp heat, cyclic (condensing)

Damp heat, cyclic tests are carried out according to basic standard IEC Publication 60068-3-4, Bibliography [10], and IEC Publication 60068-2-30, Bibliography [11] and according to Table 6.

Note: This test applies to cases where condensation is important and when the instrument is to be installed in high cyclic temperature environments.

Table 6 - Damp heat, cyclic test

Environmental phenomena	Test specification	Test set-up
Damp heat, cyclic	Temperature variations for 24 hours. Reference temperature at 95 % relative humidity. Upper temperature limit at 93 % relative humidity.	IEC 60068-2-30 IEC 60068-3-4

Supplementary information to the IEC test procedures:

Object of the test: To verify compliance with the provisions in 4.1.1 or 4.1.2 under conditions of high humidity and cyclic temperature changes.

Test procedures in brief:

Precondition: None required.

Condition of the EUT: Normal power "off" for the duration of the test unless otherwise specified.

The handling of the EUT shall be such that condensation should occur on the EUT during the temperature rise.

Stabilisation: All parts of the EUT are within 3 °C of their final temperature.

24 hour cycle sequence:

- (a) Temperature rise during the first 3 hours.
- (b) Temperature maintained at the upper limit until 12 hours from start of the cycle.
- (c) Temperature lowered to reference limit within 3-6 hours.
- (d) Temperature maintained at the reference limit until the 24-hour cycle is completed.

Number of test cycles: At least one cycle.

Test information: After stabilisation of the EUT at reference temperature, apply at least five different test loads or simulated loads and record:

- a) date and time;
- b) temperature;
- c) relative humidity;
- d) power supply voltage;
- e) test loads;
- f) indications (as applicable);
- g) errors;
- h) functional performance.

Allow full recovery of the EUT before any other tests are performed.

Maximum allowable variations: All functions shall operate as designed.
All errors shall be within the maximum permissible errors specified in 2.2.2 Table 3.

A.7.2.4 AC mains voltage variation (2.7.2, 4.3.6)

AC mains voltage variation tests are carried out according to basic standard IEC Publication 61000-4-1, Bibliography [12] and IEC Publication 61000-4-11 as detailed in Bibliography [13] and according to Table 7.

Table 7 - AC mains voltage variation

Environmental phenomena	Test specification	Test set-up
Mains voltage variation	Nominal voltage $U_{\max} + 10\%$ $U_{\min} - 15\%$ Nominal voltage	IEC 61000-4-1 IEC 61000-4-11
Notes: (1) In the case of three-phase mains power, the voltage variation shall apply for each of the phase successively. (2) The nominal voltage is the value marked on the measuring instrument.		

Supplementary information to the IEC test procedures

Object of the test: To verify compliance with the provisions in 4.1.1 or 4.1.2 under conditions of AC mains voltage variations.

Test procedures in brief:

Precondition: None required.

Condition of the EUT: Normal power supplied and "on" for a time period equal to or greater than the warm-up time specified by the manufacturer. Power is to be "on" for the duration of the test. Adjust the EUT as close to zero indication as practicable prior to the test. If it has an automatic zero setting function then the instrument should be set to zero after applying each level of voltage.

Number of test cycles: At least one cycle.

Weighing test: The EUT shall be tested at no load and with one test load or simulated load between 50 % and maximum capacity of the EUT.

Test sequence: Stabilize the power supply at the reference voltage within the defined limits and record:

- a) date and time;
- b) temperature;
- c) relative humidity;
- d) power supply voltage;
- e) test loads;
- f) indications (as applicable);
- g) errors;
- h) functional performance.

Repeat the test weighing for each of the voltages defined in IEC 1000-4-11 section 5 (noting the need in certain cases to repeat the test weighing at both ends of the voltage range) and record the indications.

Maximum allowable variations: All functions shall operate as designed. All errors shall be within the maximum permissible errors specified in 2.2.2 Table 3.

A.7.2.5 DC mains or battery power (internal) supply voltage variation (2.7.2 and 4.3.7)

Electronic instruments with DC mains or battery power (internal) supply voltage variation shall fulfil the tests in A.7.2, with the exception of A.7.2.4, which is to be replaced by the test according to basic standard IEC Publication 60654-2 as detailed in Bibliography [14] and according to Table 8.

Table 8 – DC mains or battery power (internal) supply voltage variation

Environmental phenomena	Test specification	Test set-up
DC mains or battery power (internal) supply voltage variation	U_{nom}	IEC 60654-2
	U_{max}	
	U_{min}	
Note: U_{min} and U_{max} are the DC levels at which the instrument has been manufactured to automatically detect low and high levels conditions respectively.		

Supplementary information to the IEC test procedures:

Object of the test: To verify compliance with the provisions in 4.1.1 or 4.1.2 under conditions of DC mains voltage variation.

Test procedure in brief: The test consists of exposure to the specified power supply condition when operating under normal atmospheric conditions with one test load or simulated load.

Preconditioning: None

Condition of the EUT: Normal power supplied and "on" for a time period equal to or greater than the warm-up time specified by the manufacturer. Adjust the EUT as close to zero indication as practicable, prior to

the test.

Number of test cycles: At least one cycle.

Weighing test : Stabilize the power supply at supply at the reference voltage within the defined limits and record the following data at no load and with one load or simulated load:

- a) date and time;
- b) temperature;
- c) relative humidity;
- d) power supply voltage;
- e) test load;
- f) indications (as applicable);
- g) errors;
- h) functional performance

Reduce the power voltage to the EUT until the instrument ceases to function properly according to the specifications and metrological requirements, and record the indications

Maximum allowable variations: All functions shall operate as designed. All errors shall be within the maximum permissible errors specified in 2.2.2 Table 3.

A.7.2.6 Power from external 12 V and 24 V road vehicle batteries (2.7.2, 4.3.7)

The upper limits specified for this test are in accordance with ISO 16750-2, Bibliography [15] and according to Table 10.

Table 10 - Voltage variations of 12 V and 24 V road vehicle batteries

Environmental phenomena	Test specification			Test set-up
	U_{nom}	(U_{min})	(U_{max})	
Voltage variations of a road vehicle battery	12 V	9 V	16 V	ISO 16750-2
	24 V	16 V	32 V	
Note: The nominal voltage (U_{nom}) of the electrical system in road vehicles is usually 12 V or 24 V. But the practical voltage at the battery-terminals can vary considerably.				

Supplementary information to the ISO test procedures:

Object of the test: To verify compliance with the provisions in 4.1.1 or 4.1.2 under conditions of road vehicle batteries voltage variations.

Test procedure in brief: The test consists of exposure to the specified condition of the battery when the former is operating under normal atmospheric conditions with one test load or simulated load.

Preconditioning: None

Condition of the EUT	Normal power supplied and "on" for a time period equal to or greater than the warm-up time specified by the manufacturer. Adjust the EUT as close to zero indication as practicable, prior to the test.
Number of test cycles:	At least one cycle.
Weighing test:	<p>Stabilize the power supply at nominal battery voltage and record the following data at no load and with one load or simulated load:</p> <ul style="list-style-type: none"> a) date and time; b) temperature; c) relative humidity; d) power supply voltage; e) test load; f) indications (as applicable); g) errors; h) functional performance. <p>Reduce the power voltage to the EUT until the instrument ceases to function properly according to the specifications and metrological requirements, and record the indications.</p>
Maximum allowable variations:	All functions shall operate as designed. All errors shall be within the maximum permissible errors specified in 2.2.2 Table 2.

A.7.3 Disturbance tests (4.1.2)

Summary of tests		
Test	Condition applied	§
Short time power reduction	sf ^(*)	A.7.3.1
Bursts	sf	A.7.3.2
Surges	sf	A.7.3.3
Electrostatic discharge	sf	A.7.3.4
Electromagnetic susceptibility	sf	A.7.3.5
Transient immunity test	sf	A.7.3.6
Electrical transient conduction for instruments powered by a road vehicle battery	sf	A.7.3.7

^(*) value of the significant fault (see T.4.2.7)

Prior to any test, the rounding error shall be set as close as possible to zero.

If there are interfaces on the instrument (or simulator), the use of these interfaces to other equipment shall be simulated in the tests. For this purpose, either an appropriate peripheral device or 3 m of interface cable to simulate the interface impedance of the other equipment, shall be connected to each different type of interface.

A.7.3.1 Mains voltage short time power reductions

Short time power reduction (voltage dips and short interruptions) tests are carried out according to basic standard IEC Publication 61000-4-11, Bibliography [13] and according to Table 11.

Table 11- Short time power reductions

Environmental phenomena	Test specification	Test set-up
Voltage dips and short interruptions	Interruption from reference voltage to zero voltage for one half cycle Interruption from reference voltage to 0 % of reference voltage for two half cycles These mains voltage interruptions shall be repeated ten times with a time interval of at least 10 seconds	IEC 61000-4-11
The reference voltage (rated voltage) shall be as defined in IEC 61000-4-11 section 5.		

Supplementary information to the IEC test procedures

Object of the test: To verify compliance with the provisions in 4.1.2 under conditions of short time mains voltage interruptions and reductions while observing the indications for one small static test load.

Test procedures in brief:

Precondition: None required.

Condition of the EUT: Normal power supplied and "on" for a time period equal to or greater than the warm-up time specified by the manufacturer. Adjust the EUT as close to zero indication as practicable, prior to the test. Zero-setting functions shall not be in operation and are not to be adjusted at any time during the test except to re-set if a significant fault has been indicated.

Number of test cycles: At least one cycle.

Weighing test and test sequence: Stabilize all factors at nominal reference conditions. Apply one load or simulated load and record:

- a) date and time;
- b) temperature;
- c) relative humidity;
- d) power supply voltage;
- e) test load;
- f) indications (as applicable);

- g) errors;
- h) functional performance.

Interrupt the power supply to zero voltage for a period equal to one half cycle and conduct the test as detailed in IEC 1000-4-11 section 8.2.1. During interruption observe the effect on the EUT and record as appropriate.

Reduce the power supply to 0 % of reference voltage for a period equal to two half cycles and conduct the test as detailed in IEC 1000-4-11 section 8.2.1. During reductions observe the effect on the EUT and record, as appropriate.

Maximum allowable variations: The difference between the weight indication due to the disturbance and the indication without the disturbance either shall not exceed 1 d, or the EUT shall detect and act upon a significant fault.

A.7.3.2 Electrical fast transients/burst immunity

Electrical bursts tests (fast transient tests) are carried out according to basic standard IEC 61000-4-4 Bibliography [16], and according to Tables 12.1 and 12.2, for 2 minutes with a positive polarity and for 2 minutes with a negative polarity.

Table 12.1: Ports for signal lines and control lines

Environmental phenomena	Test specification	Test set-up
Fast transient common mode	0.5 kV (peak) 5/50 ns T_1/T_h 5 kHz rep. frequency	IEC 61000-4-4
Note: Applicable only to ports or interfacing with cables whose total length exceed 3 m according to the manufacturer's functional specification.		

Table 12.2: Input and output AC and DC power ports

Environmental phenomena	Test specification	Test set-up
Fast transient common mode	1 kV (peak) 5/50 ns T_1/T_h 5 kHz rep. frequency	IEC 61000-4-4
Note: DC power ports, not applicable to battery-operated appliance that cannot be connected to the mains while in use.		

A coupling/decoupling network shall be applied for testing AC power ports.

Supplementary information to the IEC test procedures

Object of the test: To verify compliance with the provisions in 4.1.2 under conditions where fast transients are superimposed on the mains voltage while observing the indications for one small static test load.

Test procedures in brief:

Precondition: None required.

Condition of the EUT: Normal power supplied and “on” for a time period equal to or greater than the warm-up time specified by the manufacturer. Adjust the EUT as close to zero indication as practicable, prior to the test. Zero-setting functions shall not be in operation and are not to be adjusted at any time during the test except to re-set if a significant fault has been indicated.

Stabilization: Before any test stabilize the EUT under constant environmental conditions.

Weighing test: Stabilize all factors at nominal reference conditions.

Apply one load or simulated load and record the following with and without the transients:

- a) date and time;
- b) temperature;
- c) relative humidity;
- d) test load;
- e) indications (as applicable);
- f) errors;
- g) functional performance.

Maximum allowable variations: The difference between the weight indication due to the disturbance and the indication without the disturbance either shall not exceed 1 *d*, or the EUT shall detect and act upon a significant fault.

A.7.3.3 Electrical surges

Electrical surge tests are carried out according to IEC 61000-4-5 Bibliography [17] and according to Table 13.

Note: This test applies to instruments in outdoors and/or indoors installations connected to long signal lines (lines longer than 30 m or those lines partially or fully installed outside the buildings regardless of their length).

Table 13 – Surge tests

Environmental phenomena	Test specification	Test set-up
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Electrical surges	1.0 kV (peak) 3 positive and 3 negative surges	IEC 61000-4-5
Note: If the EUT is an integrating instrument, the test pulses shall be continuously applied during the measuring time.		

Supplementary information to the IEC test procedures:

Object of the test:	To verify compliance with the provisions in 4.1.2 under conditions where electrical surges are applied on the power supply lines while observing the indications for one small static test load.
Test procedures in brief:	On AC mains supply lines at least 3 positive and 3 negative surges shall be applied synchronously with AC supply voltage in angles 0°, 90°, 180° and 270°. On any other kind of power supply at least three positive and three negative surges shall be applied. The duration of the test shall not be less than one minute for each amplitude and polarity. The injection network on the mains shall contain blocking filters to prevent the surge energy being dissipated in the mains.
Precondition:	The characteristics of the generator shall be verified before connecting the EUT.
Condition of the EUT:	Normal power supplied and «on» for a time period equal to or greater than the warm-up time specified by the manufacturer. Adjust the EUT as close to zero indication as practicable, prior to the test. Zero-setting functions shall not be in operation and are not to be adjusted at any time during the test except to re-set if a significant fault has been indicated.
Stabilisation:	Before any test stabilise the EUT under constant environmental conditions.
Weighing test:	With the single static weight in place record the following with and without electrical surges: <ul style="list-style-type: none"> a) date and time; b) temperature; c) relative humidity; d) test load; e) indications (as applicable); f) errors; g) functional performance.
Maximum allowable variations:	The difference between the weight indication due to the disturbance and the indication without the disturbance

either shall not exceed 1 d, or the EUT shall detect and act upon a significant fault.

A.7.3.4 Electrostatic discharge

Electrostatic discharge tests are carried out according to basic standard IEC 61000-4-2 Bibliography [18], with test signals and conditions as given in Table 14.

Table 14 - Electrostatic discharge test

Environmental phenomena	Test specification	Test set-up
Electrostatic discharge	8 kV air discharge 6 kV contact discharge	IEC 61000-4-2
Note: The 6 kV contact discharge shall be applied to conductive accessible parts. Metallic contacts e.g. in battery compartments or in socket outlets are excluded from this requirement.		

Contact discharge is the preferred test method. Twenty discharges (ten with positive and ten with negative polarity) shall be applied on each accessible metal part of the enclosure. The time interval between successive discharges shall be at least 10 seconds. In the case of a non-conductive enclosure, discharges shall be applied on the horizontal or vertical coupling planes as specified in IEC 61000-4-2. Air discharges shall be used where contact discharges cannot be applied. Tests with other (lower) voltages than those given in Table 14 are not required.

Supplementary information to the IEC test procedures

Object of the test: To verify compliance with the provisions in 4.1.2 under conditions where electrostatic discharges are applied while observing the indications for one small static test load.

Test procedures in brief:

Precondition: None required.

Condition of the EUT: Normal power supplied and «on» for a time period equal to or greater than the warm-up time specified by the manufacturer. Adjust the EUT as close to zero indication as practicable, prior to the test. Zero-setting functions shall not be in operation and are not to be adjusted at any time during the test except to re-set if a significant fault has been indicated.

Stabilization: Before any test stabilize the EUT under constant environmental conditions.

Weighing test: Stabilize all factors at nominal reference conditions.

Apply one load or simulated load between 50 % and maximum capacity of the EUT and record the following with and without electrostatic discharge:

- a) date and time;
- b) temperature;
- c) relative humidity;
- d) test load;
- e) indications (as applicable);
- f) errors;
- g) functional performance.

Maximum allowable variations: The difference between the weight indication due to the disturbance and the indication without the disturbance either shall not exceed 1 d, or the EUT shall detect and act upon a significant fault.

A.7.3.5 Electromagnetic susceptibility

A.7.3.5.1 Radiated radio frequency, electromagnetic fields

Radiated, radio frequency, electromagnetic field immunity tests are carried out in accordance to IEC 61000-4-3 Bibliography [19], and according to Table 15.

The unmodulated carrier of the test signal is adjusted to the indicated test value. To perform the test the carrier is in addition modulated as specified.

Table 15 - Radiated electromagnetic susceptibility

Test specification				
Environmental phenomena	Frequency ranges MHz	Severity Levels (V/m)		Test set-up
		Residential, commercial and light industrial environment	Industrial environment	
Electromagnetic field of general origin	80 to 800 ⁽¹⁾	3 V/m	10 V/m	IEC 61000-4-3
	26 to 800 ⁽²⁾ 960 to 1400			
Electromagnetic field caused by digital radio telephones	800 to 960 1400 to 2000	10 V/m		IEC 61000-4-3
Modulation	80 % AM, 1 kHz sine wave			
Notes	(1) IEC 61000-4-3 only specifies test levels above 80 MHz. For frequencies in the lower range the test methods for conducted radio frequency disturbances are recommended (A.7.3.5.2). (2) However, for EUT having no mains or other input port available the lower limit of the radiation test should be 26 MHz.			

Supplementary information to the IEC test procedures

Object of the test:	To verify compliance with the provisions in 4.1.2 under conditions of specified electromagnetic fields applied while observing the indications for one small static test weight.
Test procedures in brief:	
Precondition:	None required.
Condition of the EUT:	Normal power supplied and «on» for a time period equal to or greater than the warm-up time specified by the manufacturer. Adjust the EUT as close to zero indication as practicable, prior to the test. Zero-setting functions shall not be in operation and are not to be adjusted at any time during the test except to re-set if a significant fault has been indicated.
Stabilization:	Before any test stabilize the EUT under constant environmental conditions.
Weighing test:	<p>Stabilize all factors at nominal reference conditions. Apply one static weight or simulated weight and record the following with and without electromagnetic fields:</p> <ul style="list-style-type: none">a) date and time;b) temperature;c) relative humidity;d) test load;e) indications (as applicable);f) errors;g) functional performance.
Maximum allowable variations:	The difference between the weight indication due to the disturbance and the indication without the disturbance either shall not exceed 1 d, or the EUT shall detect and act upon a significant fault.

A.7.3.5.2 Conducted radio frequency, electromagnetic fields

Conducted, radio-frequency, electromagnetic field immunity tests are carried out in accordance to IEC 61000-4-6 Bibliography [20], and according to Table 16.

The unmodulated carrier of the test signal is adjusted to the indicated test value. To perform the test the carrier is in addition modulated as specified.

Table 16 - Conducted electromagnetic susceptibility

Test specification				
Environmental phenomena	Frequency range MHz	Severity Levels (e.m.f)		Test set-up
		Residential, commercial and light industrial environment	Industrial environment	
Conducted EM field	0.15 to 80	3 V	10 V	IEC 61000-4-6
Modulation	80 % AM, 1 kHz sine wave			
Note: This test is not applicable when the EUT has no mains or other input port.				

Coupling and decoupling devices shall be used for appropriate coupling of the disturbing signal (over the entire frequency range, with a defined common-mode impedance at the EUT port) to the various conducting cables connected to the EUT.

Supplementary information to the IEC test procedures:

Object of the test: To verify compliance with the provisions in 4.1.2 under conditions of specified conducted electromagnetic fields while observing the indication for one small static test weight.

Test procedures in brief:

Precondition: None required.

Condition of the EUT: Normal power supplied and "on" for a time period equal to or greater than the warm-up time specified by the manufacturer. Adjust the EUT as close to zero indication as practicable, prior to the test. Zero-setting functions shall not be in operation and are not to be adjusted at any time during the test except to re-set if a significant fault has been indicated.

Stabilisation: Before any test stabilise the EUT under constant environmental conditions.

Weighing test: With the single static weight in place record the following with and without electromagnetic fields:

- a) date and time;
- b) temperature;
- c) relative humidity;
- d) test load;
- e) indications (as applicable);
- f) errors;
- g) functional performance.

Maximum allowable variations: The difference between the weight indication due to the disturbance and the indication without the disturbance either

shall not exceed 1 d, or the EUT shall detect and act upon a significant fault.

A.7.3.6 Electrical transient conduction for instruments powered by a road vehicle battery

A.7.3.6.1 Conduction along supply lines of 12 V and 24 V batteries

For this test refer to ISO 7637-2 Bibliography [21], and according to Table 17.

Table 17 - Conduction along 12 V and 24 V supply lines

Test specification					
Environmental phenomena	Test pulse	Pulse voltage U_s		Unit	Test set-up
		$U_{nom}=12\text{ V}$	$U_{nom}=24\text{ V}$		
Conduction along 12 V and 24 V supply lines	2a	+50	+50	V	ISO 7637-3
	2b ⁽¹⁾	+10	+20	V	
	3a	-150	-200	V	
	3b	+100	+200	V	
	4	-7	-16	V	
Notes:	(1) Test pulse 2b is only applicable if the instrument is connected to the battery via the main (ignition) switch of the car, i.e. if the manufacturer has not specified that the instrument is to be connected directly (or by its own main switch) to the battery.				
	(2) This test is primarily intended as a basis for contracts between manufacturers of motor vehicles and electronic sub-assemblies.				

Supplementary information to the ISO test procedures

Applicable standards ISO 7637-2 § 5.6.2: Test pulse 2a + b,
§ 5.6.3: Test pulse 3a + 3b,
§ 5.6.4: Test pulse 4

Object of the test To verify compliance with the provisions in 4.1.2 under the following conditions while observing the indication for one small static test weight :

- transients due to a sudden interruption of currents in a device connected in parallel with the device under test due to the inductance of the wiring harness (pulse 2a);
- transients from DC motors acting as generators after the ignition is switched off (pulse 2b);
- transients on the supply lines, which occur as a result of the switching processes (pulses 3a and 3b);
- voltage reductions caused by energizing the starter-motor circuits of internal combustion engines (pulse 4).

Test Procedures in brief:

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Preconditioning:	None
Condition of the EUT	Normal power supplied and "on" for a time period equal to or greater than the warm-up time specified by the manufacturer. Adjust the EUT as close to zero indication as practicable prior to the test. Zero-setting functions shall not be in operation and are not be adjusted at any time during the test except to re-set if a significant fault has been indicated.
Stabilisation	Before any test, stabilize the EUT under constant environmental conditions.
Weighing test:	The test consists of exposure of the EUT to conducted disturbances (on the power voltage by direct brief coupling on supply lines) of the strength and character as specified in Table 17. With the static load in place record: <ul style="list-style-type: none"> a) date and time; b) temperature; c) relative humidity; d) test load; e) indications (as applicable); f) errors; g) functional performance. Repeat the test weighing for the defined voltages and record the indications.
Maximum allowable variations:	The difference between the weight indication due to the disturbance and the indication without the disturbance either shall not exceed 1 d, or the EUT shall detect and act upon a significant fault.

A.7.3.6.2 Electrical transient conduction via lines other than supply lines

For this test refer to ISO 7637-3 Bibliography [22], and according to Table 18.

Table 18 – Electrical transient conduction via lines other than supply lines

Test specification					
Electrical transient conduction via lines other than supply lines	Test pulse	Pulse voltage U_s		Unit	Test set-up
		$U_{nom}=12\text{ V}$	$U_{nom}=24\text{ V}$		
	a	+60	-80	V	
	b	+40	+80	V	ISO 7637-3
Note: This test is primarily intended as a basis for contracts between manufacturers of motor vehicles and electronic sub-assemblies.					

Supplementary information to the ISO test procedures:

Applicable standards ISO 7637-3, § 4.5: Test pulses a and b

Object of the test To verify compliance with the provisions in 4.1.2 under conditions of

transients which occur on other lines as a result of the switching processes (pulses a and b).

The test shall be performed with one small test load only.

Test procedure in brief:

Preconditioning: None

Condition of the EUT Normal power "on" for a time period equal to or greater than the warm-up time specified by the manufacturer. Adjust the EUT as close to zero indication as practicable prior to the test. Zero-setting functions shall not be in operation and are not to be adjusted at any time during the test except to re-set if a significant fault has been indicated.

Stabilization Before any test stabilize the EUT under constant environmental conditions

Weighing test: The test consists of exposure of the EUT to conducted disturbances (bursts of voltage spikes by capacitive and inductive coupling via lines other than supply lines) of the strength and character as specified in Table 18. Record:

- a) date and time;
- b) temperature;
- c) relative humidity;
- d) test load;
- e) indications (as applicable);
- f) errors;
- g) functional performance.

Repeat the test weighing for the defined voltages and record the indications.

Maximum allowable variations: The difference between the weight indication due to the disturbance and the indication without the disturbance either shall not exceed 1 d, or the EUT shall detect and act upon a significant fault.

Note: An instrument must comply with the provisions in 4.1.2 in any type of vehicle.

A.8 Span stability test (4.4.3)

Summary of test		
Test	Characteristic under test	Condition applied
Span stability	Stability	1/2 absolute MPE ^(*)

^(*) MPE: maximum permissible error on initial verification in 2.2.2 Table 2.

Note: the maximum permissible error for the zero point shall also be taken into consideration.

Test method:	Span stability.
Object of the test:	To verify compliance with the provisions in 4.4.3 after the EUT has been subjected to the performance tests.
Reference to standard:	No reference to international standards can be given at the present time.
Test procedures in brief:	<p>The test consists of observing the variations of the error of the EUT or simulator under sufficiently constant ambient conditions (reasonable constant conditions in a normal laboratory environment) at various intervals: before, during, and after the EUT has been subjected to performance tests.</p> <p>The performance tests shall include the temperature test and, if applicable, the damp heat test; an endurance test shall not be included. Other performance tests listed in this Annex may be performed.</p> <p>The EUT shall be disconnected twice from the mains power supply (or battery supply where fitted) for at least 8 hours during the period of the test. The number of disconnections may be increased if so specified by the manufacturer or at the discretion of the approval authority in the absence of any specification.</p> <p>In the conduct of this test, the operating instructions for the instrument as supplied by the manufacturer shall be considered.</p> <p>The EUT shall be stabilized at sufficiently constant ambient conditions after switch-on for at least five hours, and at least 16 hours after the temperature and damp heat tests have been performed.</p>
Test severities:	<p>Test duration: 28 days or the time period necessary to conduct the performance tests, whichever is less.</p> <p>Time (t) between tests (days): $0.5 < t < 10$.</p>

Test load:	Near maximum capacity (Max); the same test weights shall be used throughout the test.
Maximum allowable variations:	The variation in the errors of indication shall not exceed half the absolute value of the maximum permissible error in 2.2.2 Table 3 for the test load applied on any of the n measurements.
Number of tests (n):	At least eight, except where the difference of the results indicates a trend more than half the allowable variation specified, the measurements shall be continued until the trend comes to rest or reverses itself, or until the error exceeds the maximum allowable variation.
Precondition:	None required.
Test equipment:	Verified mass standards or simulated load.
Condition of the EUT:	Normal power supplied and “on” for a time period equal to or greater than the warm-up time specified by the manufacturer.
Test sequence:	<p>Stabilize all factors at nominal reference conditions.</p> <p>Adjust the EUT as close to zero as possible. Automatic zero-tracking shall be made inoperative and automatic built-in span adjustment device shall be made operative.</p> <ul style="list-style-type: none"> • Initial measurement <p>Determine the span error using the following method:</p> <p>(1) Determine the initial zero error (E_0)</p> <p>If necessary disable any automatic zero-setting or zero-tracking devices by placing a “zero weight” of for example 10 times the scale interval on the load receptor. Note the indication at zero (I_0).</p> <p>Either by use of an indicator with a suitable higher resolution scale interval or using the change point weight method in A.3.6.2.1 (noting the total addition change point weight ΔL_0) determine and record the initial zero error (E_0).</p> <p>(2) Determine the error at near Max capacity (E_L)</p> <p>Carefully remove the change point weights (if used) and apply the test load (or simulated load) and note the indication (I_L). Either by use of an indicator with a suitable</p>

higher resolution scale interval or using the change point weight method in A.3.6.2.1 (noting the total addition change point weight ΔL) determine and record the error at near Max capacity (E_L).

Record:

- a) date and time;
- b) temperature;
- c) barometric pressure;
- d) relative humidity;
- e) value of $0.1 d$;
- f) test load;
- g) total of added change point weights at zero load ΔL_0 ;
- h) total of added change point weights at test load ΔL ;
- i) the following indications:
 - indication at zero (I_0);
 - indication of test load (I_L);
- j) calculate:
 - initial zero error E_0 ;
 - error at test load (E_L);
- k) change in location and apply all necessary corrections resulting from variations of temperature, pressure, etc. between the various measurements.

Immediately repeat steps (1) and (2) four more times and determine and record the average value of the error for the five tests.

- Subsequent measurements

After observing the time between measurements requirement repeat the test sequence (1) to (2) once recording the data above unless:

- either the result is outside the maximum allowable variation, or
- the range of the five readings of the initial measurement is more than $0.1 d$, in which case continue four more times repeating steps (1) and (2) recording the data above and determine and record the average value of the error of the five tests.

The measurements shall continue until there are at least eight measurements except where the difference of the results indicates a trend more than half the allowable variation specified, the measurements shall be continued until the trend comes to rest or reverses itself, or until the

error exceeds the maximum allowable variation.

A.9 PROCEDURE FOR IN-SITU TESTS

A.9.1 General

Note the accuracy class required for wagon weighing and train weighing.

Ensure that the desired scale interval and the maximum wagon mass comply with 2.2.2. Check that the minimum capacity complies with 2.5.

For type approval, tests shall be carried out in accordance with the requirements of this Recommendation.

For initial verification, tests shall be carried out corresponding to the normal site operation of the instrument.

A.9.2 Control instrument

Establish whether or not the WIM instrument is to be used as an integral control instrument. If it is an integral control instrument then it shall comply with 6.1.2 and be tested in accordance with 6.2 and A.5.2.

If wagons have to be moved over some distance from a separate control instrument to the EUT, the conditions must be closely controlled. Differences in weather conditions may cause errors which will not be determinable and so this should be avoided where possible.

A.9.3 Weighing

A.9.3.1 Static weighing test

When the WIM instrument is provided with a static weighing mode, the static weighing test detailed at A.5.2.2.2 shall be applied. When the instrument has been tested according to the test at A.9.2 then those results may be used.

A.9.3.2 Wagon weighing

A.9.3.2.1 Full-draught weighing of reference wagons

The conventional true value of the reference mass (uncoupled, coupled or total train) shall be determined by full-draught weighing of the reference wagons with the appropriate load conditions on a suitable control instrument.

A.9.3.2.2 Partial weighing of reference wagons

A.9.3.2.2.1 Rail-alignment correction

In accordance with the requirements in 6.1.3 for single-axle weighing instruments, the rail-alignment correction procedure in Annex B shall be applied to the totalised indicated mass of each reference wagon determined by partial weighing.

A.9.3.2.2.2 Partial weighing using separate or integral control instrument

The conventional true value of the reference wagon mass shall be determined for the reference wagon appropriately such that the axle weighing cover, as far as practicable, the weighing range of the instrument. With the wagon stationary and the wheels on the axle being weighed fully supported by the load receptor, a minimum of five different axle weighing for each appropriately loaded single-axle shall be conducted using the following method.

Weigh each axle of the static two-axle rigid reference vehicle in-turn on the control instrument (6.1) and record the indications. After both axles have been weighed, calculate the mass of the two-axle wagon by the summation of the recorded values for the two axles and record the totalised value.

Apply the alignment correction procedure determined in A.9.3.2.2.1 to the totalised value.

A.9.3.2.3 Determining the conventional true value of the reference wagon mass

Select the required number of reference wagons as specified in 6.4.

Weigh each reference wagon in-turn on the control instrument and record the indicated wagon mass. This operation shall be conducted five times with the minimum number of reference wagons and appropriate loading conditions for each wagon in accordance with 6.4.

For each of the above weighing operations, ensure that the wagon is stationary, with the wagon being weighed fully supported by the load receptor.

- (1) Calculate the mean static reference mass for each wagon according to the following:

$$\overline{\text{Wagon}_i} = \frac{\sum_{i=1}^5 \text{Wagon}_i}{5}$$

where

i is the single wagon rank
 5 is the number of weighments of each static wagon,
 Wagon_i is the recorded mass for that wagon

- (2) For the purposes of this Recommendation, the conventional true value of reference wagon mass shall be the mean value of the wagon mass as calculated in (1) above.

Alternatively, for partial weighing of static two-axle wagons, calculate the mean static reference mass for the two-axle wagon according to the following:

- 1) Weigh each axle of the two-axle wagon on the load receptor and record the indicated single axle-weights. Ensure that the wagon is stationary and conduct the weighing operation five times for each single-axle loaded appropriately as specified in A.9.3.1.3.
- 2) Calculate the mean static reference axle-mass for each axle:

$$\overline{Axle_i} = \frac{\sum_{i=1}^5 Axle_i}{5}$$

where

i is the single-axle rank
 5 is the number of weighments of each static axle,
 Axle_i is the recorded mass for that axle

- 3) Summate the two mean single-axle mass to determine the mean of the reference wagon mass:

$$\overline{Wagon} = \sum_{i=1}^2 \overline{Axle_i}$$

- 4) Apply the alignment correction procedure given in Annex B to the totalised value to determine the conventional true value of the reference wagon mass.

A.9.3.3 In-motion weighing tests with the reference wagons

A.9.3.3.1 General requirements

Prior to any test adjust the instrument under test in-situ and in accordance with the manufacturer's specifications.

All weighing operations shall be started with the reference wagon positioned in advance of the approach apron at a distance sufficient for the wagon to reach and maintain constant test speed before arriving at the apron and during each in-motion test.

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Test runs shall be conducted using the minimum number of reference wagons with the appropriate loading conditions for each wagon in accordance with 6.4.

For each reference wagon the number of test runs shall be as specified in 6.5 carried out over the centre of the load receptor.

All test runs shall be conducted at operating speeds that are within the range of speeds for which the instrument is to be evaluated, with at least each test run close to the:

- (i) maximum operating speed (s_{max}),
- (ii) minimum operating speed (s_{min})
- (iii) typical site operating speed.

A.9.3.3.2 Uncoupled wagon weighing (5.1.3.2.1)

- (1) For each uncoupled reference wagon, record the mass of the wagon as indicated or printed by the instrument under test. Calculate the difference (error) in each recorded wagon mass and its respective static reference wagon mass determined in A.9.3.2.3.
- (2) The maximum difference (error) between any recorded wagon mass and the conventional true value of the static reference wagon mass shall comply with the requirements in 2.2.1.1.

A.9.3.3.3 Coupled-wagon weighing (5.1.3.2.2)

- (1) For each coupled reference wagon, record the mass of the individual wagons as indicated or printed by the instrument under test. Calculate the mean mass of each individual wagon of the test runs conducted at the typical site operating speed:

$$\overline{Wagon_i} = \frac{\sum_{i=1}^n Wagon_i}{n}$$

where

i is the wagon rank

n is the number of test runs

$Wagon_i$ is the recorded mass for that individual wagon

- (2) Summate the mean mass values of the individual wagons to determine the mean total mass of the coupled reference wagon:

$$\overline{Coupledwagon_i} = \sum_{i=1}^w \overline{Wagon_i}$$

where

w is the number of individual wagons in that reference coupled-wagon.

- (3) Calculate the corrected mean mass for the individual wagons as follows:

$$\overline{\text{CorrWagon}}_i = \overline{\text{Wagon}}_i \times \frac{\text{Coupledwagon}_{\text{ref}}}{\text{Coupledwagon}}$$

where

$\text{Coupledwagon}_{\text{ref}}$ is the conventional true value of the mass of the coupled reference wagon determined by full-draught weighing as specified in 6.7.

- (4) For the purpose of providing traceability, the sum of the corrected mean mass for the individual wagons in the coupled reference wagon should equal the conventional true value of the total mass of the coupled reference wagon:

$$\text{Coupledwagon}_{\text{ref}} = \sum_{i=1}^w \overline{\text{Corrwagon}}_i$$

where

w is the number of individual wagons in the coupled reference wagon

Calculate the deviation of each coupled reference wagon mass from its respective static coupled reference wagon mass. Any errors shall comply with the requirements in 2.2.1.1.

- (5) Calculate the deviation of each individual wagon mass from its respective:

- a) static reference wagon mass, and
- b) corrected mean wagon mass.

Any errors shall comply with the requirements in 2.2.1.1 for the applicable accuracy class.

A.9.3.3.4 Train weighing (5.1.3.2.2)

Tests are the same as in A.9.3.3.3 and may be carried out in conjunction with A.9.3.3.3 without repeating the test, if both modes of operation are required.

The mass of the reference wagons shall be summed and any errors shall comply with the requirements in 2.2.1.2 and applied to the summation.

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ANNEX B (MANDATORY)

PRACTICAL INSTRUCTIONS FOR THE ALIGNMENT CORRECTION OF SINGLE-AXLE WEIGHING INSTRUMENTS

B.1 General

The alignment correction shall only be applied to instruments that operate by partial weighing of two-axle wagons under the conditions in 6.1 and is not recommended as a substitute for verification of reference wagons by full draught weighing.

B.2 Exemption

Instruments that operate by partial weighing are exempt from the alignment check provided the following:

- the top surface of both rails along the length of the weigh zone are vertically aligned to ± 1 mm, and
- the alignment has been checked along both rails at not less than two positions on the load receptor and not less than two positions within a wagon length from the load receptor on each associated apron.

B.3 Alignment check

The alignment correction is conducted with the use of a two-axle uncoupled static wagon similar to those wagons used for in-motion testing. Each single-axle shall be tested at two different axle loads, e.g. one near Min (empty wagon) and one near Max (wagon loaded with standard weights specified in (4)). The weighing operations are conducted as follows:

- 2) Weigh each axle of the two-axle wagon in the centre and at each end of the load receptor and record the indicated single axle-loads. Ensure that the wagon is empty and stationary and conduct the weighing operation once for each axle.
- 3) Calculate the mean static reference axle-load for each axle:

$$\overline{Axle_i} = \frac{\sum_{i=1}^3 Axle_i}{3}$$

where

i is the single-axle rank
3 is the number of weighments of each static axle,
 $Axle_i$ is the recorded load for that axle

- 3) Summate the two mean single-axle loads to determine the mean of the total mass of the empty static wagon:

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$$\overline{\text{EmptyWagon}} = \sum_{i=1}^2 \overline{\text{Axle}_i}$$

- 4) Repeat weighing operations in (1) to (3) using the specified standard weights evenly distributed the empty wagon. The sum of the standard weights used shall be at least equal to the larger of the following values:
 - a) the difference between the maximum capacity and 1.5 times the weight of the wagon as determined in (3), with the result rounded down to the nearest 1 tonne;
 - b) ten tonnes.
- 5) The difference between the value obtained in (3) for the empty static wagon and the value in (4) for the loaded static wagon shall be subtracted from the total value of the standard weights, the result being the alignment correction.
- 6) The absolute value of the alignment correction shall be added to the totalized indicated weight of each reference wagon weighed while stationary and uncoupled on a single-axle weighing instrument.
- 7) Example of alignment correction test sheet:

Accuracy class: 1

Maximum capacity: $a = 35 \text{ t}$

Typical wagon tare: $b = 11.5 \text{ t}$

Mass of standard weight required: $c = 17 \text{ t}$ ($a - 1.5 b$, to nearest tonne)

Scale interval: 0.1 t

Scale interval for stationary load: 0.01 t

Summary of test report

	Position on load receptor	Indicated mass (t)	
		Empty wagon	Loaded wagon
First axle	Leading end	5.76	14.27
	Middle	5.75	14.26
	Trailing end	5.75	14.26
Second axle	Leading end	5.75	14.25
	Middle	5.75	14.25
	Trailing end	5.74	14.24
Total of six weighings		34.50	85.53
Divide total by three		$d = 11.50$	$e = 28.51$
Derived mass of standard weight		$f = e - d = 17.01$	
Alignment correction		$c - f = -0.01$	

The absolute alignment correction value is used to obtain the corrected the totalized indicated mass, for example, if the totalized indicated mass is 41.38 t , the corrected mass will be:

$$41.38 + (-0.01) = 41.37 \text{ t}$$

Note: The calibration correction computed in this example is not intended to be typical.

ANNEX C (INFORMATIVE)

GENERAL INSTRUCTIONS FOR THE INSTALLATION AND OPERATION OF AUTOMATIC RAIL-WEIGHBRIDGES

C.1 Installation of WIM instruments

The mandatory installation requirements are subject to change in recognition of future technical developments.

C.2 Weigh zone

The weigh zone shall comprise a load receptor with an apron on both ends.

C.3 Apron construction

The aprons in advance of and beyond the load receptors shall consist of a stable, load bearing structure made of durable material resting on a suitable foundation to provide a straight, smooth, approximately-level plane surface to support all wheels of a wagon simultaneously as the wagon passes over the load receptors.

C.4 Spilt material and ice

Care shall be taken in the design and operation of the installation to ensure that, as far as possible, a build-up of spilt material and ice on the weigh zone of the instrument either does not occur, or is removed regularly.

C.5 Overhead structures

Load receptors shall not be installed beneath a loading or conveying mechanism from which loose material might fall.

C.6 Tare weighing

The time between tare weighing and gross weighing operations associated with a particular load shall be minimal.

C.7 Notice of speed restrictions

There shall be means to ensure that all drivers of vehicles that cross the load receptor are aware of the minimum and maximum operating speeds at which they can proceed.

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